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Meteorology Research, Inc, Altadena, Calif

Prepared for

Corvallis Environmental Research Lab, Oreg

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Volume I: Technical Summary

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Final Report
June 1977

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Prepared by
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Altadena, California

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Final Report

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Prepared by

METEOROLOGY RESEARCH, INC.
Altadena, California

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FOREWORD

Stringent thermal discharge limitations established by EPA in accordance with Sections 301 and 306 of the Federal Water Pollution Control Act Amendments of 1972 (pl 92-500) have led to an increased use of cooling towers by utilities as one alternative to once-through cooling for steam electric power plants. Cooling towers have potential impacts which should be evaluated, along with engineering, economic, and social implications, when selecting cooling systems for proposed new electric power plants.

As part of the Chalk Point (Maryland) Cooling Tower Project (CPCTP), the Electric Power Research Institute and United States Environmental Protection Agency have sponsored an airborne monitoring program at the world's largest operating brackish water natural draft cooling tower. The overall objective of the CPCTP is to characterize all emissions from the cooling tower and assess the impact on the surrounding environment. Specific objectives of this study were to: 1) characterize the downwind transport of water vapor and salt drift in the cooling tower plume, 2) investigate chemical interactions of the cooling tower and combustion stack plumes under merging conditions, and 3) evaluate the potential hazards of turbulence, icing, and impaired visibility to aircraft which may travel through the plume.

Taken in its entirety, this report represents, in our opinion, the most complete and detailed data base on natural draft cooling tower plume characteristics available in the open literature. As such, this report should be of considerable value to the scientific community, utility companies, and regulatory agencies for testing cooling tower plume models, planning future cooling tower applications, and evaluating their attendant environmental effects.

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Environmental Assessment Department
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U.S. Environmental Protection Agency

ABSTRACT

MRI conducted an airborne plume monitoring program as part of the Chalk Point Cooling Tower Project. Plume measurement included:

Temperature
Dew Point
Visibility
Turbulence
Droplet Size Distribution and Concentration
Liquid Water Content
Sodium Chloride Concentration ($NaCl$)
Sulfuric Acid Concentration (H_2SO_4)
Sulfur Dioxide Concentration (SO_2)

Vertical cross sections of the plume were mapped at several downwind distances ranging from 80 m (264 ft) to 8 km (5 mi). Data were recorded every half second to provide the short response times required for accurate plume profile measurements.

The presence of stable visible plumes was observed during cold high humidity conditions. Even under these conditions, however, the decrease in visibility is not considered to be a hazard to aircraft because of the limited distance over which it extends.

Interactions between the cooling tower plume and the boiler plume are limited. The boiler plume is saturated with water from combustion products and from a venturi wet scrubber. Therefore, chemical reactions that require moisture have occurred prior to mixing with the cooling tower plume, and the additional water supplied by the cooling tower plume has little effect.

Concentrations of sodium chloride and sulfuric acid were very low. Occasionally sulfuric acid was detected in the boiler plume, but it was generally below the measurable threshold sensitivity (4 $\mu g/m^3$ for droplets larger than 30 μm and 150 $\mu g/m^3$ for smaller droplets). Droplets containing sodium chloride reached concentrations up to 1000 droplets/m^3. The largest droplets were approximately 400 μm diameter. Typical mass median diameters were approximately 200 μm. Assuming a sodium chloride concentration of 5 percent (5-10 times the concentration in the tower circulating water), the highest sodium chloride concentrations measured in the plume were on the order of 65 $\mu g/m^3$.

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SUMMARY

The primary objective of MRI's participation in the Chalk Point Cooling Tower Project was to provide detailed airborne measurements of the cooling tower plume parameters. These measurements included dew point, temperature, visibility, turbulence, droplet size distributions, droplet concentrations, total liquid water content, sulfuric acid mist, sulfur dioxide, and salt drift. The data were tabulated, presented graphically, and analyzed for potential aircraft hazards. Results are to be correlated later with measurements inside the tower and on the ground in the vicinity of the tower.

Plume measurements were made for: (1) the visible and vapor plume, (2) the drift droplet plume, and (3) interactions of the cooling tower plume with the boiler plume. The STOL equipped, fixed-wing light aircraft used to make plume measurements provided an excellent instrument platform, and the entire instrumentation system gave exceptionally high reliability. The loss of data because of instrument failure was approximately five percent.

The following conclusions have been drawn as a result of the plume measurements made by MRI.

1. Water Vapor Content

Water vapor content in the plumes can be measured most effectively with the fast response Lyman-Alpha optical absorption sensor. Its fast response and high sensitivity are ideally suited for mapping water vapor cross sections within the plumes. Accuracy of the Lyman-Alpha sensor can be improved by normalizing the baseline to that of the EG&G dew point sensor. The normalization process continuously recalibrates the instrument during operation.

2. Liquid Water Content

Liquid water content in the visible and drift plumes was measured by two independent methods. One used a PMS optical droplet size spectrometer, the other used an MRI Chemical Film Sampler. The spectrometer provided excellent real time measurements, but because of the small population density of large drift droplets (greater than 50 μm dia.), it was not able to provide a statistically significant sample size in every case. The film sampler provided a higher sampling rate but was limited to droplets larger than approximately 20 μm diameter. Thus, the film sampler measurements gave larger droplet size estimates on a total mass basis. However, number size distributions were comparable between the two systems. Since the mass of one large drift droplet collected by the film sampler can equal the mass of many small droplets sampled by the spectrometer, actual size distributions in the plume are best obtained by averaging results from both instruments. The instruments appear to be complementary to each other.

3. Temperature

Temperature was adequately measured with a TSI fast response hot wire sensor. The only limit to the response time was the arbitrary half-second averaging time used in the buffer memory system and data recorder. Temperature profiles across the plume were plotted to show internal temperature variations.

4. Salt Drift

Salt drift measurements were effectively measured with the MRI Chemical Film Sampler. The sampler provided droplet size distributions of drift droplets containing sodium chloride. Approximate salt drift estimates can be made from these measurements by calculating ranges of salt concentrations expected in the droplets. Limitations include poor collection efficiency for droplets smaller than 20 μm diameter and limited sampling rates. The sampling rate, however, was still greater than any of the other instruments used. Regardless of these limitations, excellent, reproducible results were obtained. The Chemical Film Sampler is a new MRI instrument, and it appears to be a very useful tool for measuring salt drift from cooling towers. It provided measurements that were previously unattainable.

5. Potential Aircraft Hazards

Aircraft hazards that were measured included visibility, turbulence, and icing potential. Visibility was measured with the MRI nephelometer and photographs taken of the plume under varying weather conditions. Results indicated that the only time the plume is large enough to present a serious hazard, visibility will normally also be limited by natural meteorological conditions. The increase in hazard is, therefore, small compared to the natural limits of visibility caused by clouds or fog. Turbulence was measured with an MRI Universal Indicated Turbulence System. The quantitative measurements of turbulence along with subjective evaluation of turbulence intensity by the aircraft crew resulted in the conclusion that even though severe turbulence exists in and near the plumes, particularly on a calm day with high plume rise, the duration is so short that the probability of creating a serious aircraft hazard is reasonably low. Icing estimates were made based on temperature and water content measurements. Under conditions when icing could present a serious hazard, natural icing conditions also exist. As with visibility, the additional increase in hazard is small compared to the large variation in effects from natural causes.

6. Plume Interaction

Plume Interaction measurements were made with the MRI Chemical Film Sampler for sulfuric acid mist and with a Theta electrochemical sensor for SO_2. Because of the limited number of days when any plume mixing occurred, there was insufficient data available to quantitatively determine the effects of plume interactions. Qualitative evaluations, however, indicate that because the boiler stack is equipped with a venturi wet scrubber, the reactions in the interaction zone are slow compared to those that have already taken place during interaction within the scrubber plume. Additional moisture from the cooling tower plume appears to have little effect compared to the already "water rich" scrubber plume.

As a result of the successful measurements obtained during the Chalk Point Cooling Tower Project, the following recommendations are made.

1. The data collected on plume characteristics appear to be uniquely valuable, and results should be further analyzed and cataloged to provide more detailed descriptions of plume properties. Such descriptions will provide the needed quantitative input for effective plume modeling studies. These studies, in turn, will provide much better estimates of the environmental impact of cooling tower plumes including salt drift, plume rise and dispersion rates, and inadvertent weather modification.

2. Additional experimental measurements of cooling tower plumes should be made. Since the experiences with these measurement systems were positive, it is recommended that all of the instrumentation used on the current study be used again in the future studies. Because of the limited weather conditions that were encountered during the two intensive field tests, it is recommended that additional measurements be made, particularly for cold humid days when extensive visible plumes are generated.

3. A useful set of similar data should be gathered for other types of cooling towers during various climatic conditions. A circuit of sampling experiments should be performed in a comparison study to provide comparable data sets for modeling.

4. Additional studies are recommended to analyze the physical processes that control plume formation, SO_2 interactions, sulfuric acid formation, precipitation, and snow formation. Results of these studies will provide a better understanding of factors that affect plume characteristics and will make more accurate modeling possible.

SECTION 1

INTRODUCTION

This report summarizes plume characterization studies performed by Meteorology Research, Inc., (MRI) as part of the Chalk Point Cooling Tower Project (CPCTP). It is submitted to the State of Maryland in partial fulfillment of Contract 28-76-04(76).

The Chalk Point Cooling Tower Project is sponsored by the State of Maryland, with support provided by the U.S. Environmental Protection Agency (EPA), the Electric Power Research Institute (EPRI), and the U.S. Energy Research and Development Administration (ERDA).

The primary purpose of the CPCTP is to determine the environmental impact of salt drift from a brackish water natural draft cooling tower. MRI's role in the project was to make detailed measurements of the drift plume including plume dimensions, drift droplet sizes, and droplet concentrations. These determinations were made using a single engine, Cessna 205, light aircraft. Instruments on the aircraft provided continuous measurements during plume penetrations. All measurements were recorded every half-second on magnetic tape for later data reduction.

Data from the Chalk Point program can be used to compare plume characteristics with plant operating parameters under varying weather conditions. Results will provide estimates of the environmental impact including: potential fallout of sodium chloride and sulfuric acid mists; aircraft hazards from icing, turbulence, and decreased visibility; and other weather modifications, such as increased ground fog or cloud cover. The results will be useful in planning future plant designs, selecting new sites, and controlling undesirable effluents.

This report consists of four volumes:

Volume 1: Technical Summary
Volume 2: Tabulated Measurements
Volume 3: Air Quality Data Plots
Volume 4: Water Droplet Size Data Plots

The technical summary, Volume 1, describes the experimental plans, measurement techniques, and program results. Volumes 2, 3 and 4 present data collected during the June 1976 intensive field testing period. Results of the first intensive field tests, conducted during December 1975, are presented in a previous report.[1]

SECTION 2

DESCRIPTION OF EXPERIMENTS

Two intensive field tests were conducted under the Chalk Point Cooling Tower Program: one in December 1975, the other in June 1976. During these tests, MRI measured the physical and chemical properties of the cooling tower plume. Parameters measured included:

- Water Droplet Size
- Droplet Concentration
- Temperature
- Dew Point
- Turbulence
- Visibility
- SO_2 Concentration
- H_2SO_4 Concentration
- NaCl Concentration

MRI's Cessna 205, STOL equipped, light aircraft was used to make the required measurements. Results were tabulated and additional parameters calculated including relative humidity, droplet size distribution, and total liquid water content.

The instrumented aircraft system provided the capability for mapping spatial variation of plume characteristics. The primary limitation was the inability to do the mapping instantaneously. The plume size, shape, and relative location changes rapidly so that multiple sampling traverses through the same location do not necessarily give the same results even when taken a few seconds apart. All other sampling systems, however, suffer this same disadvantage. Because of the rapid plume variations, best results are obtained when as many repetitive measurements as possible are made in a short period of time.

2.1 Experimental Test Design

Three test plans were used during the intensive field test periods:

- Visible Plume Measurements
- Drift Droplet Plume Measurements
- Interaction Zone Measurements

2.1.1 Test Plan 1, Visible Plume Measurements

The aircraft sampling plan for characterizing the visible water plume from the cooling tower is illustrated in Figure 1. A number of vertical cross sections of the plume were measured at various distances downwind from the tower. These cross sections are numbered one through four in the illustration. Measurements were made along each cross section by flying back and forth through the plume at altitudes ranging from below the visible plume to above the top of the plume. Each pass through the plume was at a fixed altitude and airspeed. The true airspeed (indicated airspeed corrected for temperature and pressure variations) is very close to true ground speed for these plume traverses because the flight path is perpendicular to local wind.

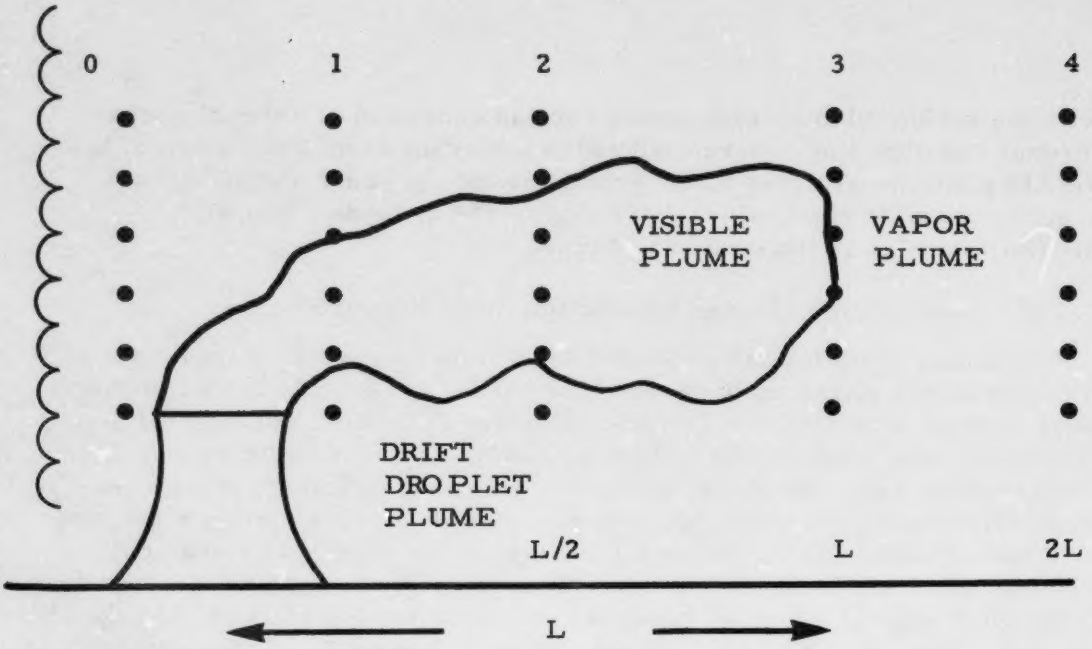
Cross section 1 was as close to the cooling tower as safety would permit, i. e., approximately 50 to 100 meters from the edge of the cooling tower for most of the tests. Cross section 2 was nominally midway between the tower and the end of the visible plume, i. e., L/2 where L is the total length of the visible plume. Cross section 3 was near the end of the visible plume. Cross section 4 was beyond the end of the visible plume, nominally at twice the length of the plume, or 2L. During many of the sampling traverses, the plume was so short that it disappeared by the time it reached plane 1.

Cross section 0 was upwind of the power plant; it was used to determine ambient background of aerosol particulate concentration, size distribution, concentration of NaCl, H_2SO_4, SO_2, ambient temperature, and dew point.

Vertical temperature and wind profiles were measured to provide accurate interpretation of the plume measurements. Vertical profiles were made by flying a tight spiral pattern, usually from 1500 meters (5000 ft) to 30 meters (100 ft) above sea level.

2.1.2 Test Plan 2, Drift Droplet Measurements

Gravitational settling causes large water droplets from the cooling tower plume to fall rapidly to the ground. The "plume" of large drift droplets is directly underneath the visible plume. It extends to the ground, and much of the fallout can occur before the end of the visible plume. Measurements of the nonvisible drift droplet plume were, therefore, made at cross sections with downwind distances similar to those of the visible plume, i. e., 0 = upwind ambient background, 1 = as close to the cooling tower as possible, 2 = half the length of the visible plume, 3 = the length of the visible plume, and 4 = twice the length of the visible plume. As


0
1
2
3
4
VISIBLE
PLUME
VAPOR
PLUME
DRIFT
DROPLET
PLUME
L/2
L
2L
L

DISTANCE DOWNWIND:

0. Upwind from source.
1. As close to the source as safety permitted
2. Approximate midpoint of the visible plume (L/2).
3. Near end of the visible plume (L).
4. Approximately double the visible plume length (2L).

SAMPLING MODE:

● Horizontal traverse.
ξ Vertical temperature sounding to 1219 m (4000 ft.)

Figure 1. Visible Plume, Test Plan No. 1

with the visible plume, each cross section consisted of several passes through the plume at different altitudes extending from the bottom of the visible plume to as close to the ground as safety would permit (usually a minimum of 75 meters, or 250 ft above the ground). The drift droplet test plan is illustrated in Figure 2.

2.1.3 Test Plan 3, Plume Interaction Zone Measurements

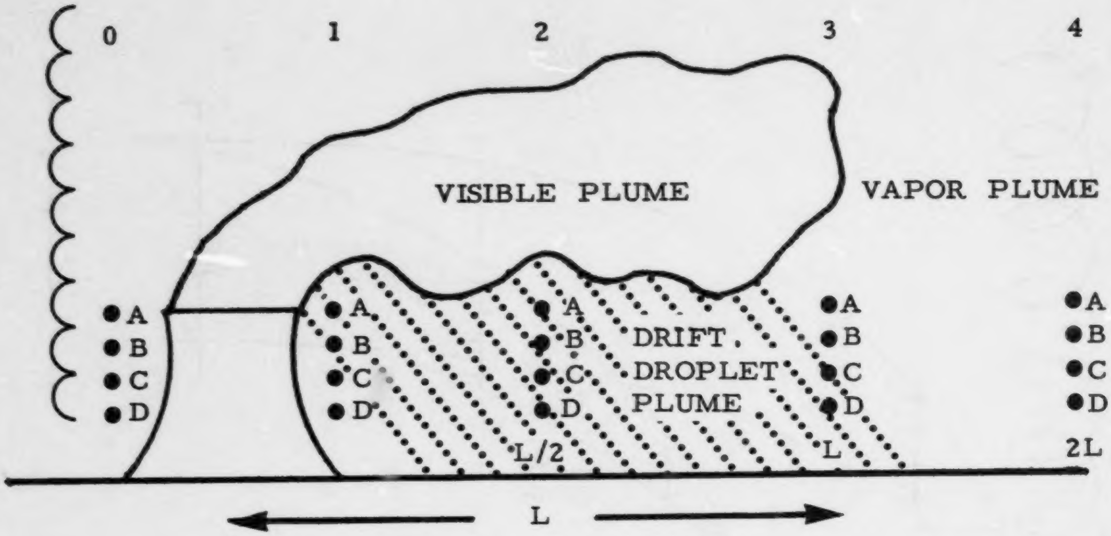
During certain meteorological conditions, the cooling tower plume mixes with the plume emitted from the boiler stack. The boiler effluents pass through a venturi wet scrubber that uses brackish water. The plume, therefore, may contain NaCl, H_2SO_4, and SO_2 in addition to water. The boiler plume can, therefore, add to the potential visibility, icing, and NaCl fallout problems. H_2SO_4 fallout may result if a significant SO_2 water reaction occurs. Water for this reaction can be supplied by either the cooling tower or the boiler plume. Measurements in the interaction zone followed a slightly different plan than those for the visible and drift droplet plumes. The basic test plan is illustrated in Figure 3. Cross section 0 is still upwind, and cross section 1 is still as close to the cooling tower as possible. Cross section 2 provides measurement of the boiler emission plume prior to mixing or interacting with the cooling tower plume. Cross section 3 was taken at a distance, D, downwind from the cooling tower where the two plumes first began to mix. The zone where mixing occurs is the potential interaction zone. Cross section 4 is near the end of the visible plumes, and cross section 5 is beyond the visible plumes.

2.1.4 Aircraft Positioning

Location of the sampling aircraft during plume passes was determined by two methods: (1) visual observation and (2) radio navigation. Visual observation is the most accurate, and it was used as the primary method. Radio navigation was used as a backup method.

For the visual observation method, two landmarks were selected from the air, one on each side of the plume where a sampling traverse was made. The aircraft flew a straight line course between the two points as a traverse of the plume was made. The positions of the landmarks were located on aerial photographs of the area and a line was drawn between the two points. Downwind distances between the cooling tower and the specific cross section being sampled were measured directly from the photographs. The scale factor of the photographs was determined by measuring the distance between two points with known spacing.

The location of the aircraft traverse path is specified by its perpendicular distance from the cooling tower and its angle from magnetic north,


0
1
2
3
4
VISIBLE PLUME
VAPOR PLUME
A
B
C
D
DRIFT
DROPLET
PLUME
L/2
L
2L
L

DOWNWIND DISTANCE:

0. Upwind from source.
1. As close to the tower as safety permitted.
2. Approximate midpoint of the visible plume (L/2).
3. Near end of the visible plume (L).
4. Approximately double the visible plume length (2L).

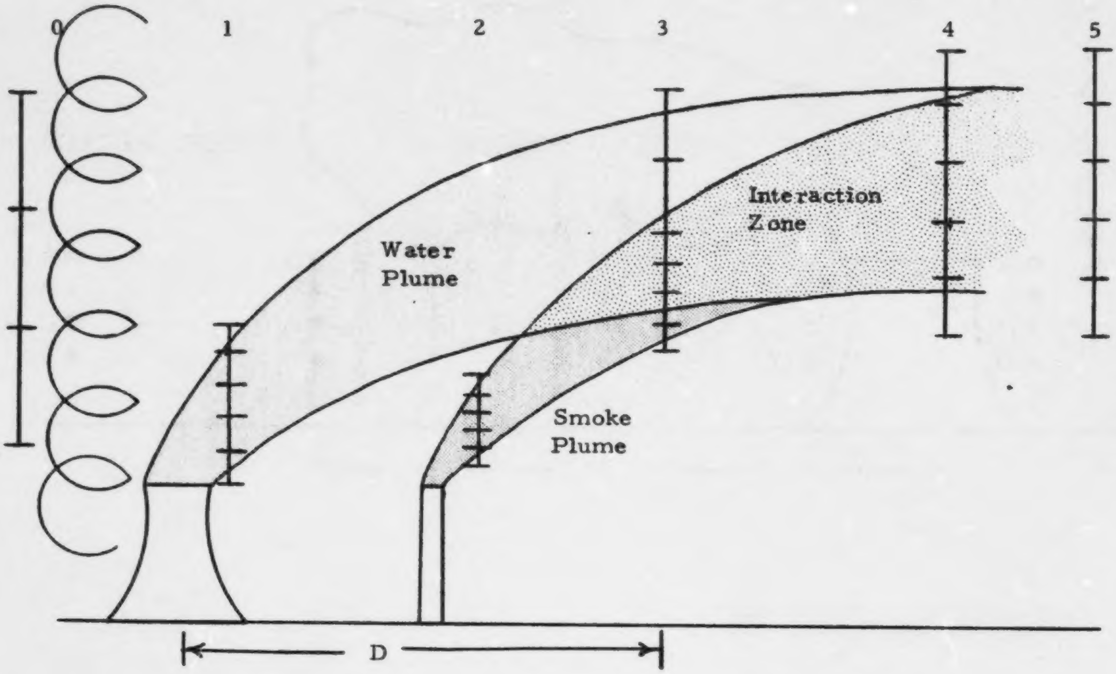
ALTITUDE:

A. Just below the visible plume.
B. Intermediate level between the visible plume and ground.
C. Intermediate level between the visible plume and ground.
D. As close to the ground as safety permitted.

SAMPLING MODE:

● Horizontal Traverse.
ξ Vertical Temperature Sounding.

Figure 2. Drift Droplet Plume, Test Plan No. 2


0
1
2
3
4
5
Water Plume
Interaction Zone
Smoke Plume
D

DOWNWIND DISTANCE:

0. Upwind from source.
1. As close to water plume source as safety would permit.
2. As close to smoke plume source as safety would permit.
3. Slightly downwind from the beginning of interaction zone.
4, 5. Selected locations in the interaction zone based on the existing meteorological environment.

SAMPLING MODE:

+ Horizontal Traverse.
ξ Vertical Temperature Sounding.

Figure 3. Plume Interaction, Test Plan No. 3.

Figure 4. It is assumed that the plume always moves with the wind. The wind direction can, therefore, be taken as the direction of the plume motion. The axis of the plume intersects the aircraft traverse path at some angle β that can be determined as illustrated in Figure 5.

Using a polar coordinate system with the cooling tower at the origin and magnetic north as the reference angle, the exact location and angle of each sampled plume cross section can be specified. In the reported data, aircraft traverse paths are dimensioned by the perpendicular distance from the cooling tower and the angle of the path from magnetic north.

Flight paths are illustrated qualitatively by Figure 6 which shows the general location of typical flight paths for tests made during June 1976 and Figure 7 for the December 1975 tests. During actual flight path determinations, aerial survey maps were used to provide more detail, greater magnification, and more accuracy.

2.2 Instrumentation and Measurement Methods

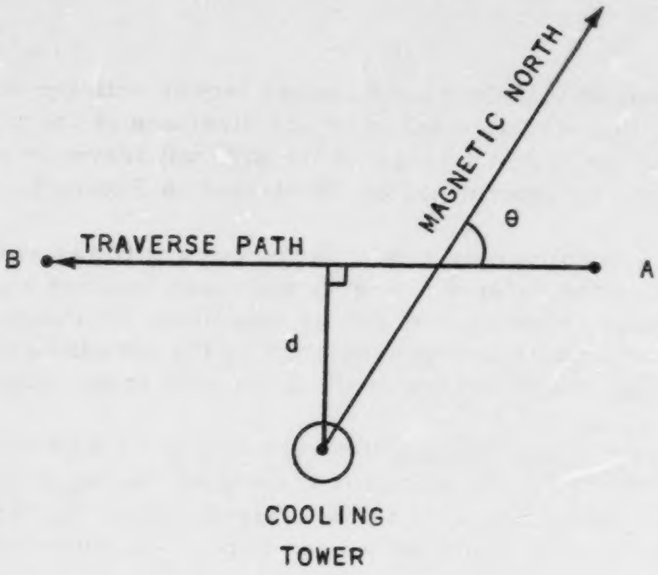
A Cessna Model 205 aircraft was used for the Chalk Point plume measurements, Figure 8. The aircraft is modified for short takeoff and landing (STOL) to permit slow flying speed during sampling. The slow speed reduces instrument response requirements during plume mapping. With the STOL addition, sampling runs can be made at approximately 31 m/sec (70 mi/hr). However, because of the close proximity to the cooling towers and stacks during most of the traverses, slightly higher speeds (36-40 m/sec) were used to provide better control of the aircraft and, therefore, improved safety.

The aircraft was modified for mounting the plume monitoring instruments. Passenger seats were replaced by electronic control panel racks, Figure 9; air intake manifolds were installed in a side window opening, Figure 10; and instrument pods were mounted on the wings. Figure 11 shows the approximate locations of wing mounted instruments.

The instruments require more electrical power than the normal aircraft system can supply. A heavy duty, 100 ampere, alternator system was installed to provide the necessary power. Heavy duty inverters were used to supply 120 volt, 60 cycle AC power to those instruments that required it.

A list of instruments used for data measurement is given in Table 1. A more complete description of the instruments is provided in Appendix A.

The MRI Chemical Film Sampler is a new instrument for measuring sodium chloride and sulfuric acid in water droplets larger than 30 microns


MAGNETIC NORTH
θ
B
TRAVERSE PATH
A
d
COOLING TOWER

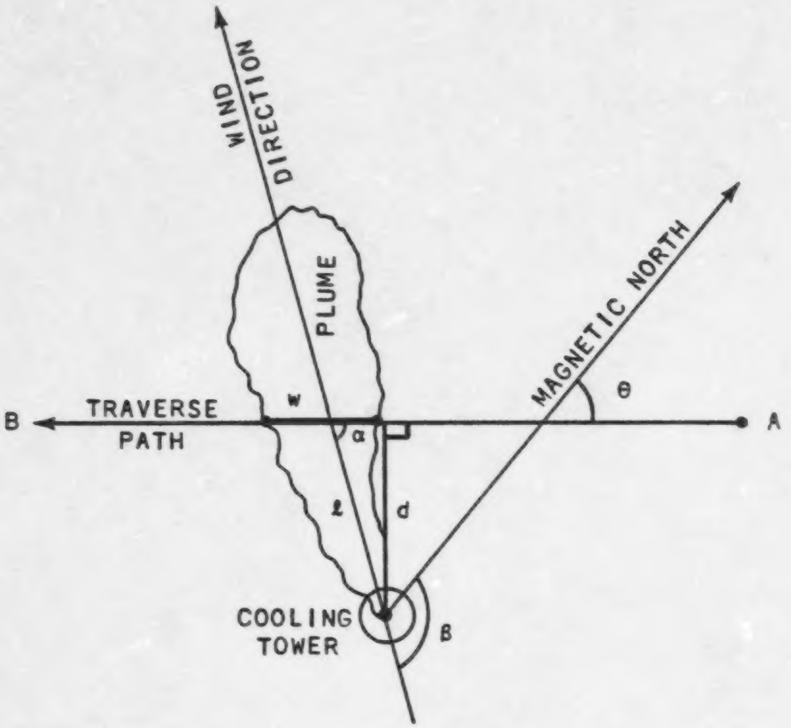
AB = Aircraft traverse path from Point A to Point B

d = Perpendicular distance from cooling tower to traverse path

θ = Deviation of traverse path from magnetic North

76-584

Figure 4. Methods of Specifying Location of Aircraft Traverse Paths


WIND DIRECTION
PLUME
MAGNETIC NORTH
θ
B
TRAVERSE PATH
w
α
A
ℓ
d
COOLING TOWER
β

AB = Aircraft traverse path from Point A to Point B

d = Perpendicular distance from cooling tower to traverse path

ℓ = Downwind distance of measured plume cross section

w = Width of measured cross section

θ = Deviation of traverse path from North

β = Wind direction

α = Angle of traverse path from plume axis ($\alpha = \beta - \theta$)

76-585

Figure 5. Methods of Determining Location and Angle of Measured Plume Cross Sections

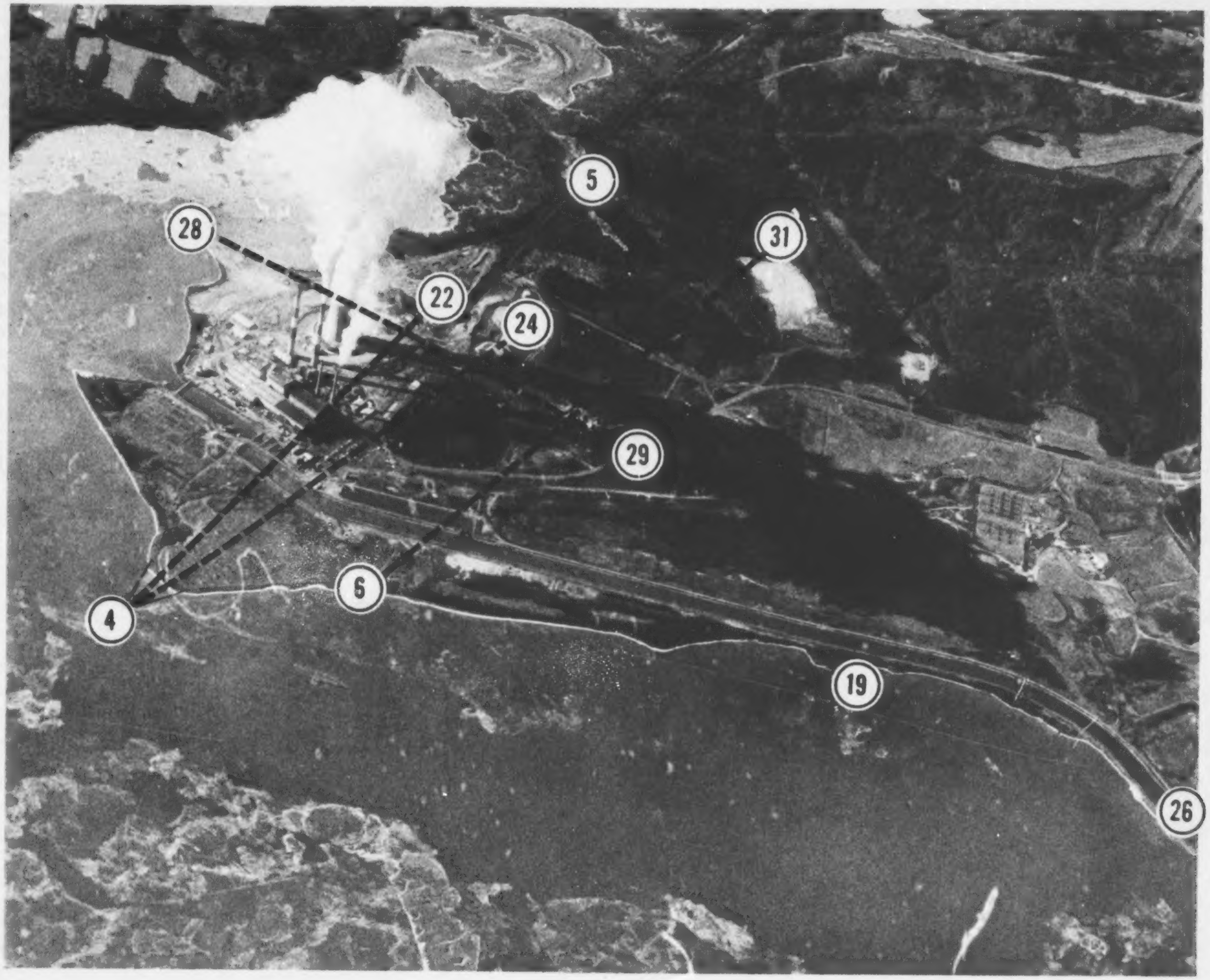

28
5
31
22
24
29
6
4
19
26

Figure 6. Aircraft Flight Paths, June 1976

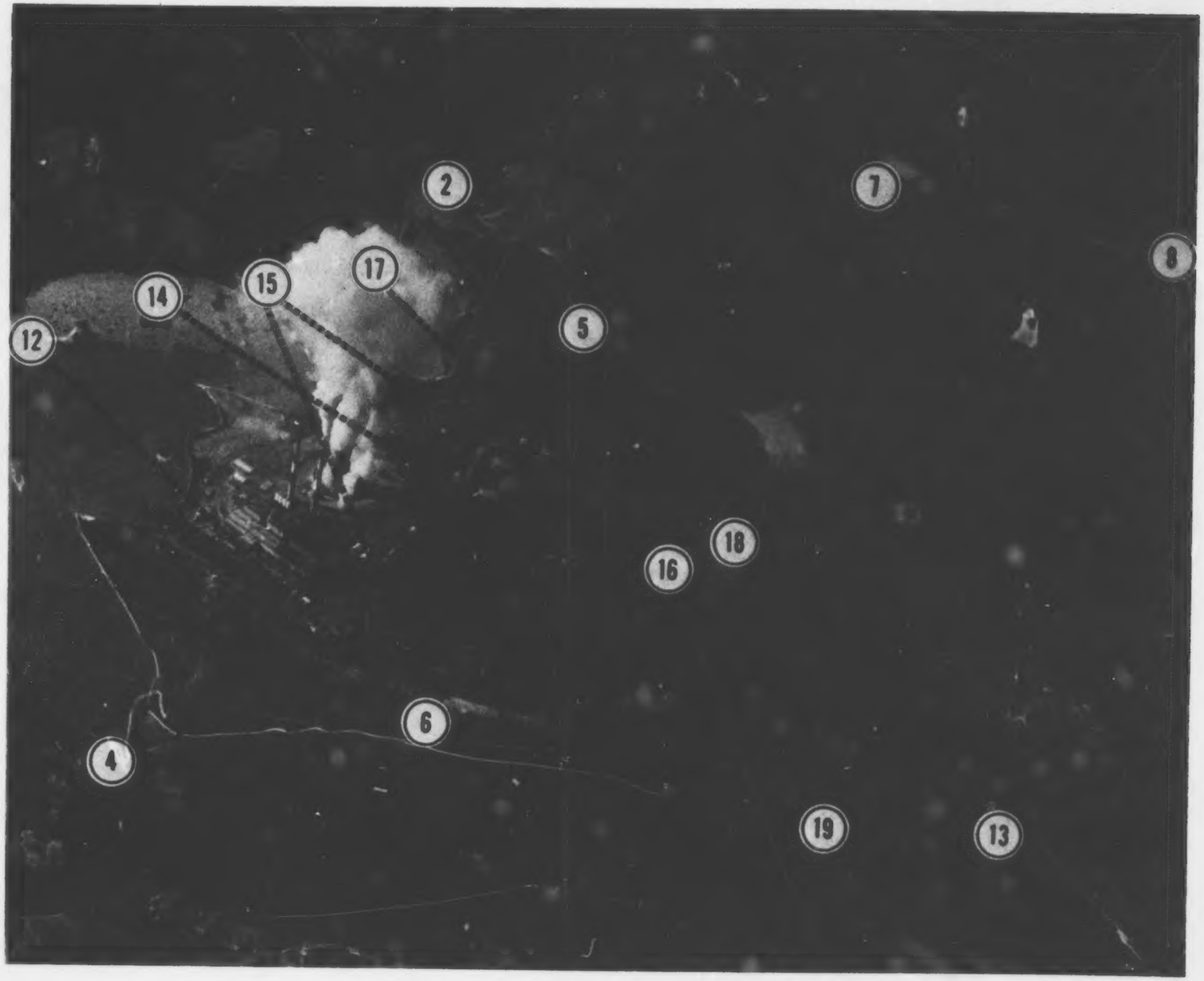

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Figure 7. Aircraft Flight Paths, December 1975

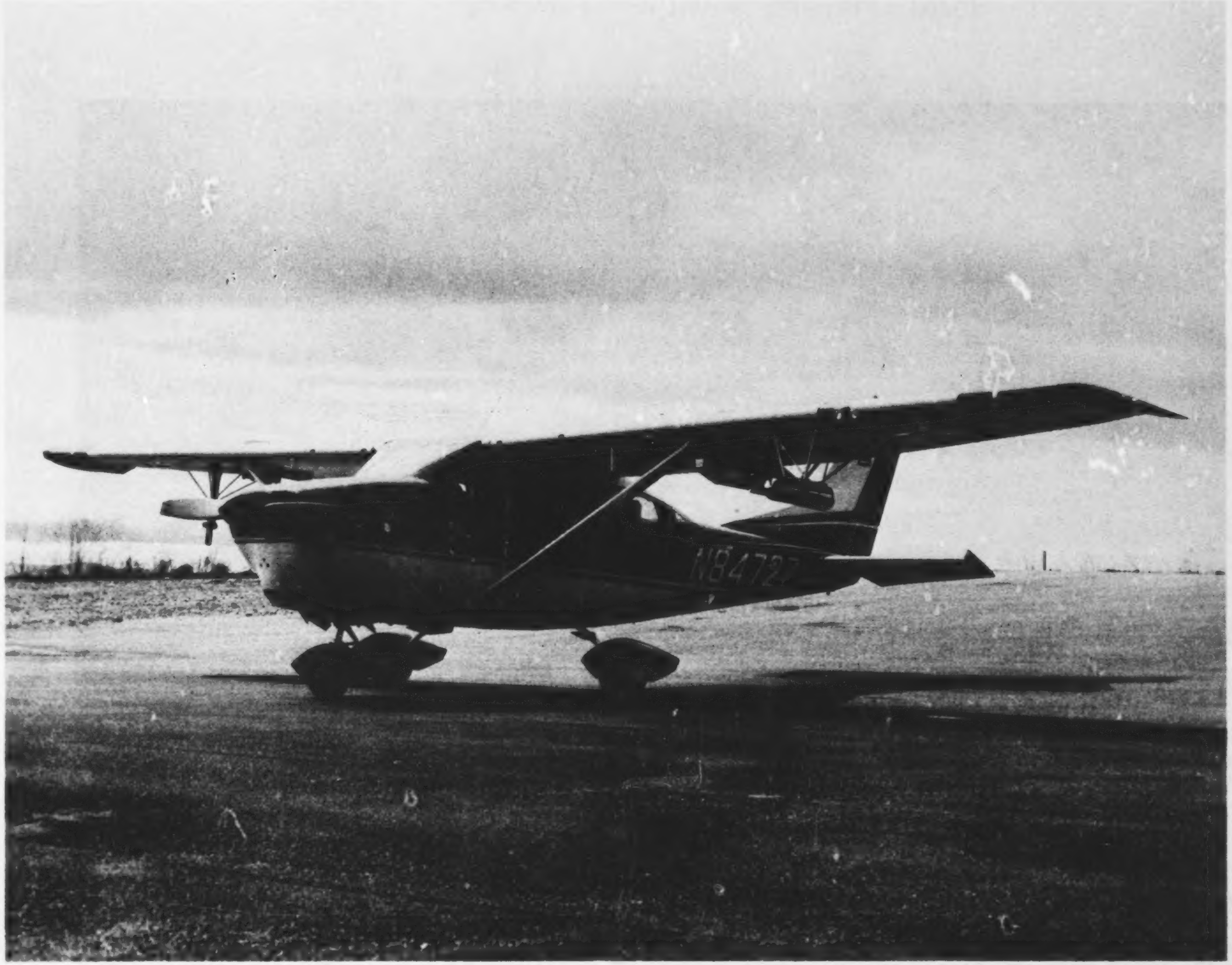
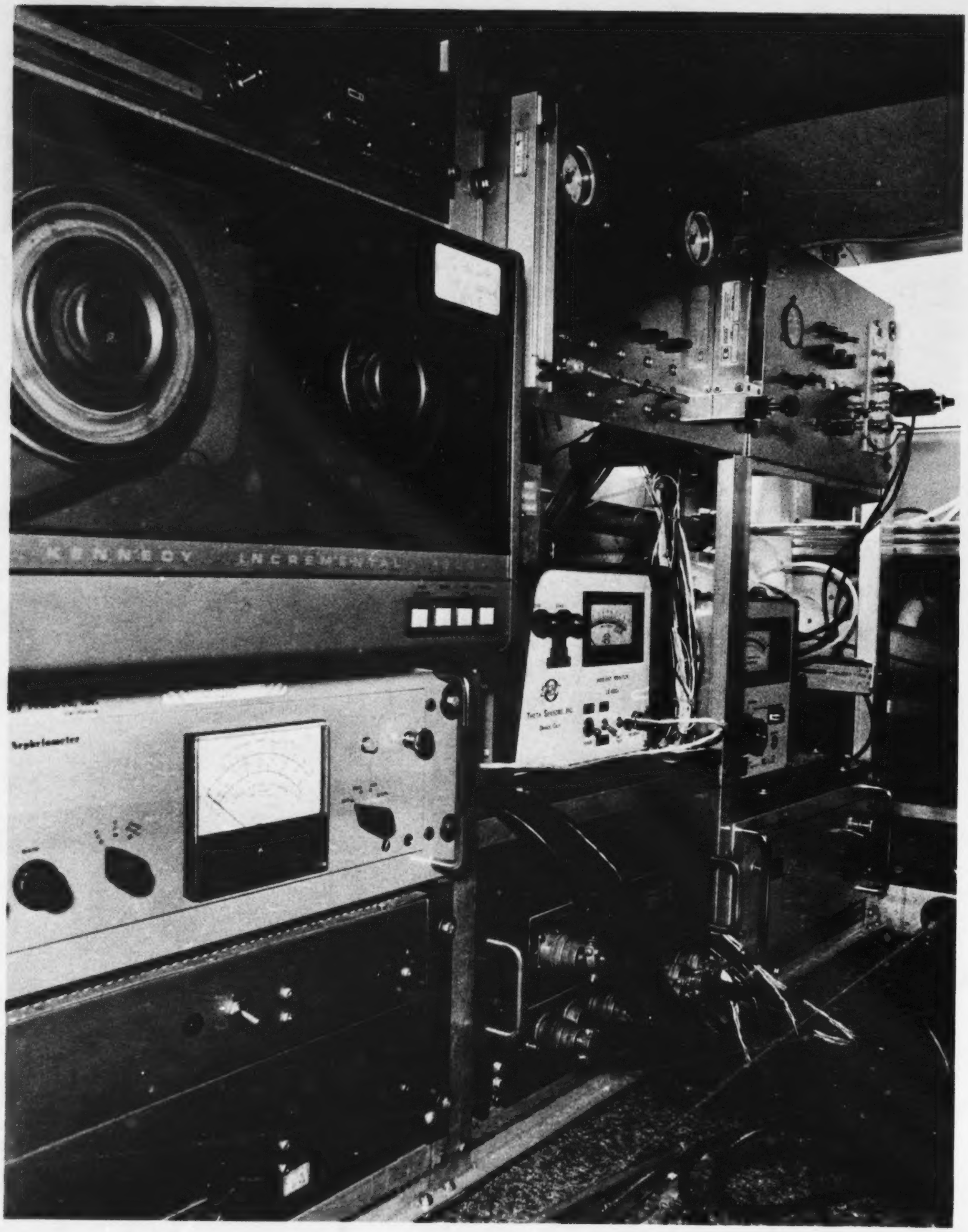


Figure 8. Cessna 205 Aircraft Instrumented for Plume Survey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Theta Sensors, Inc.

Figure 9. Control Panel in Aircraft

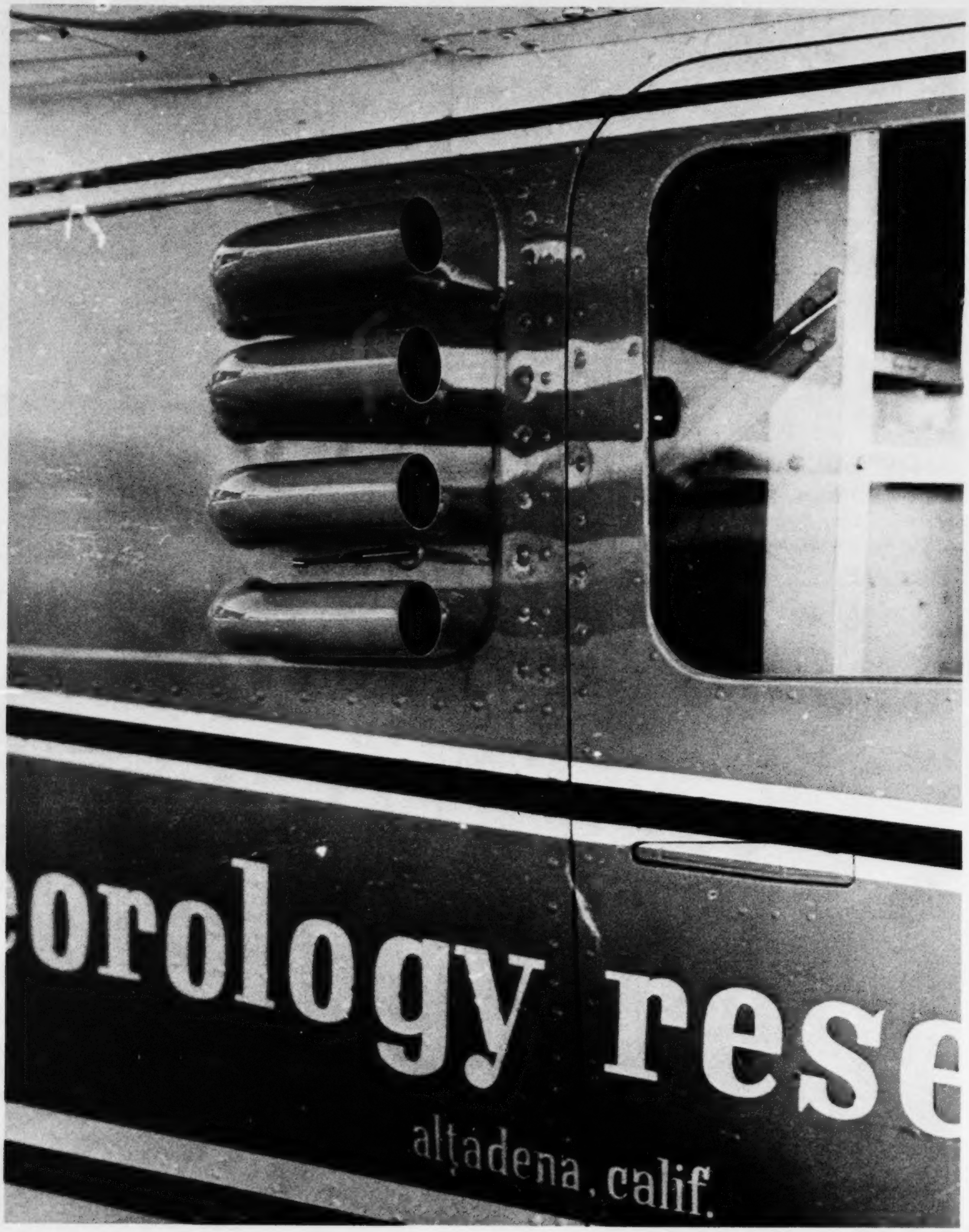

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Figure 10. Sample Intake Manifolds

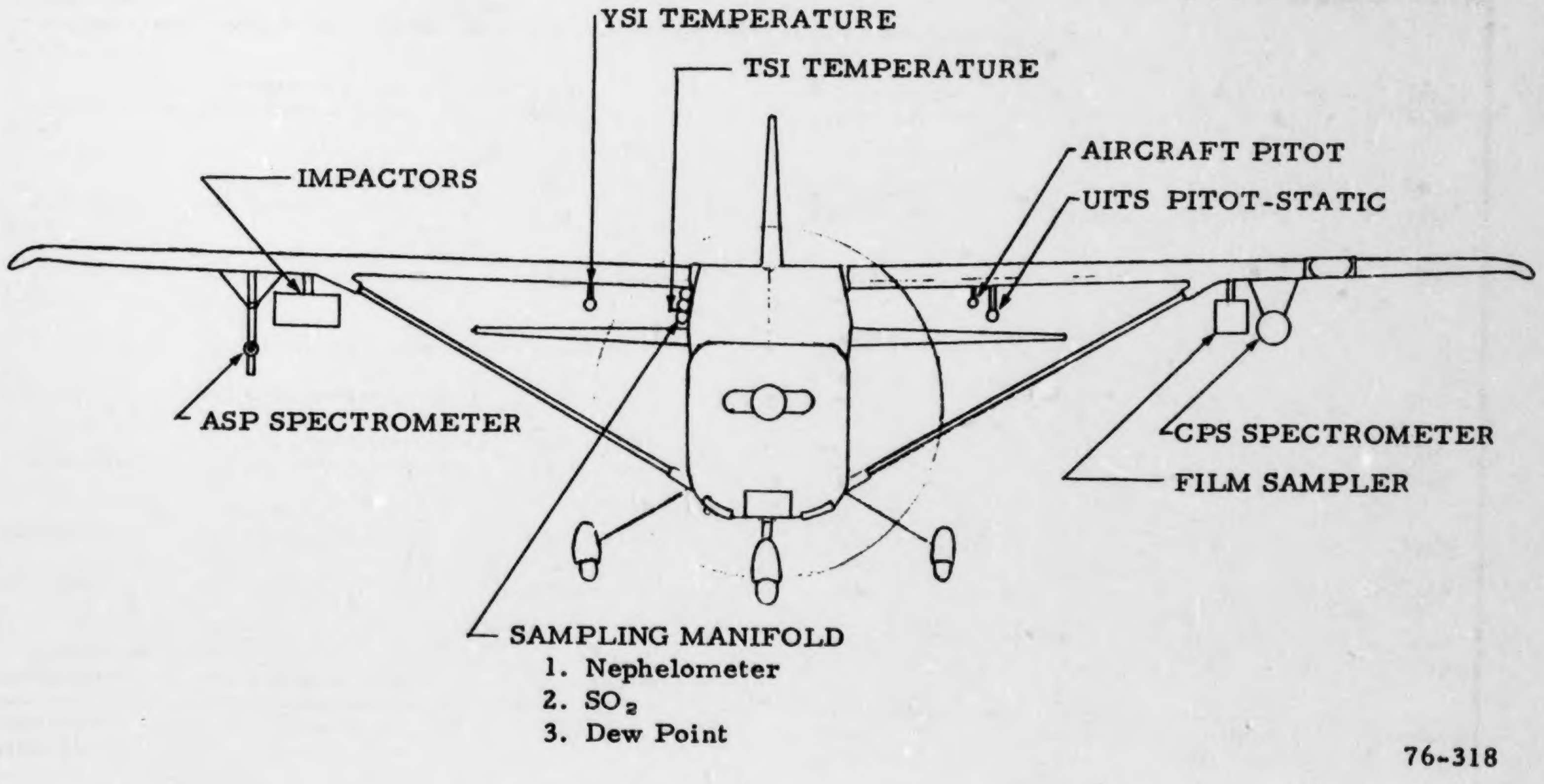
YSI TEMPERATURE
TSI TEMPERATURE
AIRCRAFT PITOT
UITS PITOT-STATIC
IMPACTORS
ASP SPECTROMETER
CPS SPECTROMETER
FILM SAMPLER
SAMPLING MANIFOLD
1. Nephelometer
2. SO2
3. Dew Point
76-318

Figure 11. Instrument Mounting on Aircraft

TABLE 1. AIRCRAFT SAMPLING INSTRUMENTS

Measured Parameter	Method	Manufacturer	Range and Units	Typical Instrument Delay Times (Sec)	Approximate Sensitivitiy	Accuracy
Droplet Size Distribution	Laser Spectrometer (1) ASP (2) CPS	Particle Measurement Systems	 0-30 μm dia. 30-300 μm dia.	 0 0	 2×10^{-4} g/m^3 10^{-3} g/m^3	 ±10% ±10%
Visibility	Nephelometer	MRI	0-100×10^{-4} m^{-1}	2	2×10^{-6} m^{-1}	{+2% -15%
Turbulence	UITS (Differential Pressure)	MRI	0-10 R units cm$^{2/3}$/sec	2	0.2 R	±10%
Temperature	(1) TSI Aspirated Hot Wire (2) YSI Vortex Thermister	Thermo Systems MRI	-30 to +50° C -30 to +50° C	0.01 5	0.2°C 0.2°C	±2°C ±1°C
Dew Point	(1) Condensation (Optical)	EG&G	0 to 100° F (-18 to 38° C)	5*	0.2°C	±1°C
	(2) Lyman Alpha Absorption	Tarantula	-18 to 38° C	0.01	0.2°C	±2°C
SO_2 Concentration	Electrochemical Cell	Theta Sensors	0-10 ppm	6	0.02 ppm	±2%
NaCl Concentration	(1) Chemical Film (2) Cascade Impactor	MRI MRI	>30 μm dia. 0.2-30 μm dia.	NA NA	10^{-6} g/m^3 2×10^{-4} g/m^3	±20% ±10%
H_2SO_4 Concentration	(1) Chemical Film (2) Cascade Impactor	MRI MRI	>30 μm dia. 0.2-30 μm dia.	NA NA	10^{-6} g/m^3 2×10^{-4} g/m^3	±20% ±20%

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*Dew Point sensor response time is approximately 2° C/sec (in the order of 10 percent relative humidity per second).

diameter. The film sampler was used for drift drops which were expected to be in the size range of 50 to 300 microns diameter. The cascade impactors were used for collecting plume droplets smaller than 30 microns.

2.3 Data Handling Methods

Raw data from all instruments except the impactors and Chemical Film Sampler were recorded automatically with a Kennedy magnetic tape recorder on standard 9-track tape. Computer programs were written to retrieve the data, process it, and provide both tabular and chart plots. A manual event marker was recorded to identify specific events as noted in the operator's log during sampling traverses or vertical profiles. Automatic event markers were also recorded during actuation of the film sampler and the cascade impactor samplers.

Raw data dumps were used to provide periodic data quality checks. The raw data were also reviewed whenever the final reduced data appeared questionable.

Substrates from the cascade impactors and film from the Chemical Film Sampler required chemical analysis to determine sodium chloride and sulfuric acid. They were analyzed with ion excited x-ray emission (IEXE) fluorescence techniques for sodium chloride and by fluorescence microscopy for sulfuric acid. Both analysis techniques require specialized laboratory facilities. Chemical treatment of the film also provided high contrast images of droplets that contained sodium chloride. These droplet images were sized and counted to determine the concentration of sodium chloride in the samples.

2.4 Meteorological Measurements

General meteorological data was recorded manually. Specific meteorological conditions including pressure altitude, temperature profiles, humidity, and visibility were recorded on magnetic data tape from the aircraft instruments. Vertical wind profiles were supplied from pibal and radiosonde measurements by the Applied Physics Laboratory (APL) of Johns Hopkins University. The meteorology summaries are available as separate APL reports, one for the December 1975 tests[2] and one for the June 1976 tests.[3]

SECTION 3

EXPERIMENTAL RESULTS

Measurements were taken continuously during the entire flight time of the aircraft; however, data reported are limited to actual plume penetration traverses in order to limit the size of the data volumes.

3.1 Description of Results

Cooling tower plume characterization measurements were made during two intensive test periods. One was in the winter, December 1975, and one was in the summer, June 1976. These periods were selected in order to represent seasonal variations in ambient weather conditions. Representative conditions included:

Date	Typical Temperatures	Typical Humidities
December 1975	5° C	50-85%
June 1976	25° C	70-95%

During December tests, gusty winds and low temperatures normally existed; during the June tests, surface winds were generally slower and more steady, and temperatures and humidity were higher. On days with the highest humidity, higher plumes were observed; in some cases recondensation of vapor plumes formed small clouds above the cooling tower.

A summary of the tests conducted during each of the seasonal test periods is given in Table 2. A complete listing of all plume traverses made during the program is given in Appendix B. Results of sodium chloride droplet measurements are tabulated in Appendix C.

3.2 Format of Results

Temperature, dew point, turbulence, visibility, droplet counts, droplet size distribution, SO_2 concentration, aircraft speed and altitude, and elapsed time were recorded on magnetic tape and later reduced to provide output in standard engineering units. These data are included in tabular form in Volume 2. Calculated liquid water content and relative humidity are also included in the tables.

TABLE 2. SUMMARY OF PLUME TESTS

Test No.	Date	Test Plan (No.)	Traverses Made	Data Recovered	Typical Temp. (°C)	Typical Relative Humidity (%)	Remarks
2	12-15-75	Visible (1)	32	80%	13°	85%	Gusty winds
3	12-16-75	Visible (1)	10	100%	7°	50%	Gusty winds
4, 5	12-17-75	Drift (2)	24	90%	5°	75%	
6	12-17-75	Interaction (3)	33	30%	6°	80%	
7	12-19-75	Interaction (3)	37	90%	-10°	45%	
8	6-17-76	Visible (1) Drift (2)	80	100%	21°	95%	
10	6-18-76	Visible (1)	26	100%	25°	80%	
11	6-18-76	Visible (1) Drift (2)	59	95%	26°	75%	
12	6-19-76	Drift (2)	76	95%	25°	75%	
13	6-21-76	Visible (1)	10	100%	25°	80%	Occasional rain droplets
14	6-22-76	Visible (1)	97	100%	24°	90%	Long visible plume
15	6-23-76	Interaction (3) Visible (1)	75	100%	21°	90%	Vertical plume extending to cloud base
16	6-24-76	Visible (1) Drift (2)	82	100%	24°	70%	Boiler plume looping
17	6-25-76	Long Range Boiler	14	100%	25°	60%	Boiler plume measured 5 miles downwind

Temperature, dew point, turbulence, visibility, and SO_2 concentration are provided in graphical form on one set of plots (Volume 3); water droplet concentrations, size distributions, and liquid water content are given on a second set of plots (Volume 4). Data are printed in separate data volumes for convenience in handling.

Concentrations of NaCl, H_2SO_4, aircraft location, and other miscellaneous data are presented in this summary volume.

3.3 Performance of Instrumentation

Instruments used in the Chalk Point Plume studies functioned exceptionally well. Less than 5 percent of the data were lost due to instrument failure during the entire program. Instrument failure included:

1. Malfunction of the ASP spectrometer laser detector resulted in intermittent loss in measurement of 0-30 μm diameter water droplets on test numbers 5 and 6.

2. A BMS/Magnetic tape recorder system failure resulted in loss of tape recorded data for traverses 22-33 during test number 6.

3. The EG&G dew point sensor failed during test number 7, resulting in loss of relative humidity data.

4. A loose electrical connection on the TSI temperature sensor resulted in loss of fast response temperature measurements on test numbers 11 and 12.

All other instruments appeared to function properly and provided acceptable data during the entire testing program.

Half-second averages of instrument outputs were recorded on magnetic tape. The half-second interval was selected as a compromise; longer times increased the statistical significance of the sample sizes, but shorter times gave more detail on rapid fluctuations within the plume.

Some instruments have delay and response times of up to several seconds. Algorithms have been developed to correct for delay times and to partially compensate for slow response times. The uncorrected data, however, are reported in all cases in order to show the effects of delay and response times. During further data analysis, care must be taken to apply the necessary correction factors. The magnitude of these corrections can be

determined by comparing results of slow instruments with those from the extremely fast instruments (i.e., PMS spectrometer, TSI temperature, or Lyman-Alpha water sensor).

SECTION 4

DISCUSSION OF RESULTS

Plume characteristics were measured for the vapor plume, the salt drift plume, and for interaction of the boiler and cooling tower plumes. In the context of this report the vapor plume is defined to include the visible condensation plume. The salt drift plume includes all drift droplets regardless of sodium chloride content. The interaction zone is the region in which the cooling tower plume mixes with the boiler plume, whether or not chemical interactions actually occur.

4.1 Vapor/Visible Plume

Most of the measurements made during the program included measurements of the vapor plume. By mapping the plume cross sections, plume boundaries and plume rise were determined.

4.1.1 Plume Cross Sections

Ideally, all of the dimensions of a plume should be mapped instantaneously. However, because a significant amount of time is required to perform multiple plume traverses, the accuracy of the plume size and shape measurements is decreased. By averaging the cross section dimensions obtained from a number of traverses, more representative measurements can be made.

The approximate width of the visible plume was determined from the traverse time through the plume and the aircraft velocity. The boundries of the visible plume were identified by the responses of the nephelometer and the PMS spectrometers. Boundaries of the pure vapor plumes were estimated from the response of the Lyman-Alpha water vapor sensors and the TSI fast response temperature sensor.

The vertical dimensions of the plume cross section were determined by observing instrument response as the altitude of successive traverses was gradually increased, starting from below the plume (or decreased starting above the plume.) The altitude limits within which positive plume detection is observed are taken as the top and bottom of the plume. Both the vertical and horizontal plume dimensions can be determined from data tables given in Volume 2 or the plots in Volumes 3 and 4.

4.1.2 Plume Rise

Plume rise is determined from the altitude of the plume. The altitude is recorded by the aircraft altimeter. In addition to the standard altimeter calibration, a qualitative evaluation of calibration is made by flying at the exact altitude of the 213-meter (700-foot) smoke stack and the 122-meter (400-foot) cooling tower and noting the altimeter readings. The ground elevation is approximately 3.6 m (12 ft) above mean sea level. The altimeter variations within a given day appear to be within approximately 3 m (10 ft). The day-to-day variation is slightly greater, perhaps 9 meters (30 ft).

The plume rise can be determined from the data tables in Volume 2. It can also be estimated from plume photographs. Representative photographs taken from the aircraft at the beginning of plume traverses are shown in Appendix D. Time lapse photographs, which were taken from the ground, were a separate task under the Chalk Point Project.

4.1.3 Plume Temperature Excess

Temperature measurements were made with two independent sensors. A TSI aspirated hot wire, fast response temperature sensor was used to provide the primary measurement of temperature variations within the plume. An MRI vortex thermistor system provided duplicate temperature measurements but with a slower time response. The hot wire system provided a response within 0.01 seconds. The data recording system averaged all data readings over half-second intervals so the measurements were not limited by the instrument response time. The TSI sensor provided excellent measurements of temperature excesses as the monitoring aircraft penetrated the plumes. Temperature excesses generally ranged from 0° to 10° C, but most were less than 4° C. They reach a peak at the plume center and gradually diminish toward the edges. Complete results of temperature measurements are included in the tables of Volume 2; they are also plotted in the graphs of Volume 3.

4.1.4 Moisture and Water Vapor Excess

Liquid water content was determined by calculating the cumulative volume of water droplets measured with the PMS droplet spectrometers. Droplets measured by both the ASP (0-30μm diameter droplets) and CPS (30-300μm diameter droplets) sensors were included in the calculation of total liquid water content. Liquid water content results are included in the data tables, Volume 2, and data plots, Volume 4. Liquid water contents generally ranged from 0-0.2 gm/m^3 in the measured plumes; most measurements were less than

0.1 gm/m^3. Highest water contents were observed early in the mornings when temperatures were low and relative humidities were near 100 percent. The liquid water determinations include both condensation droplets and drift droplets. The contribution of drift droplets alone can be determined if a minimum size for drift droplets is assumed.

Water vapor was measured during the first field tests with an EG&G dew point sensor. The response time of the EG&G sensor, approximately 2°C/sec., limited the vapor measurements to general averages. During the second field test, in June 1976, a fast response Lyman-Alpha water vapor sensor was installed to measure the "fine structure" of water vapor variations within the plume. The sensor, made by Tarantula, measures the absorption by water vapor of the Lyman-Alpha ultraviolet hydrogen emission line. Response time of the Tarantula Lyman-Alpha sensor is less than 0.01 seconds. Resolution of rapid changes in water vapor content are, therefore, limited only by the arbitrary half-second averaging time of the data recording system. If more detailed water vapor measurements are required, future measurements could be recorded with an analog recorder or shorter averaging times could be used with the digital tape recorder.

The Tarantula sensor output is a voltage that is proportional to absolute water vapor content. The dew point was calculated from the water vapor content measurements, normalized to the EG&G baseline dew point, and recorded on all of the data output tables. The results were normalized to eliminate the effect of a slow random drift in the Lyman-Alpha baseline. The EG&G baseline was used because of its greater stability. This method for "continuous correction" of the Lyman-Alpha baseline provided excellent measurements of absolute water vapor content as well as relative changes in vapor content.

A comparison of Lyman-Alpha and EG&G dew point measurements is provided in Appendix E to show how well the two instruments agree and to show the greater detail that was measured with the Lyman-Alpha sensor.

4.1.5 Particulate Concentrations In and Near the Vapor Plume

Particulate measurements were made with MRI cascade inertial impactors and the MRI nephelometer. The nephelometer does not differentiate particulates and droplets, both of which are encountered in the visible condensation plume. Particulate concentrations outside the condensation plume, however, can be adequately measured with the nephelometer. The nephelometer provides a continuous real-time measurement and is effective for showing relative changes in particulate concentrations.

Results of nephelometer measurements are given in table form in Volume 2 and as graphical plots in Volume 3.

4.1.6 Particulate Chemical Composition

The cascade impactor was used primarily to collect particles for chemical analysis. The impactor contained three stages to provide separation of the aerosol sample into four size ranges:

First Stage	15-30 μm dia.
Second Stage	3-15 μm dia.
Third Stage	0.4-3 μm dia.
Filter	<0.4 μm dia.

Impactor stages and filters were analyzed for elemental composition by Ion Excited X-Ray Emission spectroscopy (IEXE), and for sulfuric acid by fluorescence measurements. Results of the IEXE analysis are given in Appendix E. In general, they indicate the presence of the following elements in trace quantities: sodium, magnesium, aluminum, silica, sulfur, chlorine, phosphorous, vanadium, iron, manganese, titanium, and barium. The most predominant elements were iron, phosphorous, aluminum, magnesium and silica.

4.2 Salt Drift Plume

The Chalk Point Cooling tower uses brackish water containing sodium chloride. Large drift droplets will, therefore, carry a small amount of sodium chloride out of the tower. The salt will presumably be deposited on the ground in the vicinity of the cooling tower.

One of the program objectives was to determine the amount of sodium chloride being emitted and the droplet sizes in which it occurred. Using these measurements and analytical drift plume models, the fallout concentrations as functions of downwind distances can be calculated.

Salt water drift droplets were collected using the MRI Chemical Film Sampler. A description of the film sampler is given in Appendix A. It collects droplets larger than approximately 30 μm diameter by inertial impaction.

Film from the film sampler was chemically processed. The processing produces visible images from water droplets that contain sodium chloride.

When a water droplet containing salt impacts the film surface, the surface energy causes it to spread, then it is absorbed by the gelatin coating on the film. The sodium chloride from the droplet is left as a residue in the gelatin. The diameter of the salt deposit is related to the original droplet diameter by a spread factor. The spread factor is slightly dependent on droplet diameter for small droplets (less than 5 μm diameter). It becomes essentially independent of droplet size for droplets in the drift droplet size range. Because the film sampler was designed to collect droplets larger than 30 μm diameter, a constant spread factor can be assumed. Spread factors were determined experimentally and compared to those determined by other investigators (Figure 12). The spread factor for water droplets on gelatin is taken as 2, i.e., the image diameter is double the original droplet size.

Droplet images, Figure 13, from selected film samples were measured using a Quantimet optical image analyzer. Droplet size distributions, determined from the measurable images, appear to be log normal distributions with mean diameters of approximately 10-50 μm and mass median diameters of 150-300 μm diameter. The smaller droplets in this size range are at the lower limit of efficient collection by the film sampler. Estimated collection efficiency is approximately 80 percent for 20 μm droplets, 50 percent for 11 μm droplets, and 10 percent for 7 μm droplets. Complete size distributions are given in Appendix C.

Ideally, the sodium chloride concentration should be measured independently during each traverse through the drift droplet plume. Initial testing, however, indicated that because of the apparently low concentrations that were present, cumulative samples during several consecutive traverses were required. Many of the film samples, therefore, included multiple traverses within a given cross section.

In order to calculate the total sodium chloride concentration per unit volume in the drift plume, the concentration in the individual droplets must be determined. When droplets leave the tower, their salt concentration is approximately 0.5-1 percent, the same concentration as in the tower circulating water. As a droplet evaporates, the sodium chloride concentration increases until an equilibrium is reached. Vaporization rate and equilibrium concentration depend on humidity, temperature, and droplet size. Typically, however, times are expected to be on the order of 1-5 minutes after leaving the saturated vapor plume. If a droplet reaches vaporization equilibrium prior to collection, the sodium chloride will be at the maximum possible concentration, probably on the order of 30-90 percent salt depending on temperature and humidity. If the droplet has not yet reached equilibrium, then the sodium chloride concentration in the droplet will be lower than at equilibrium, but higher than at the tower exit.

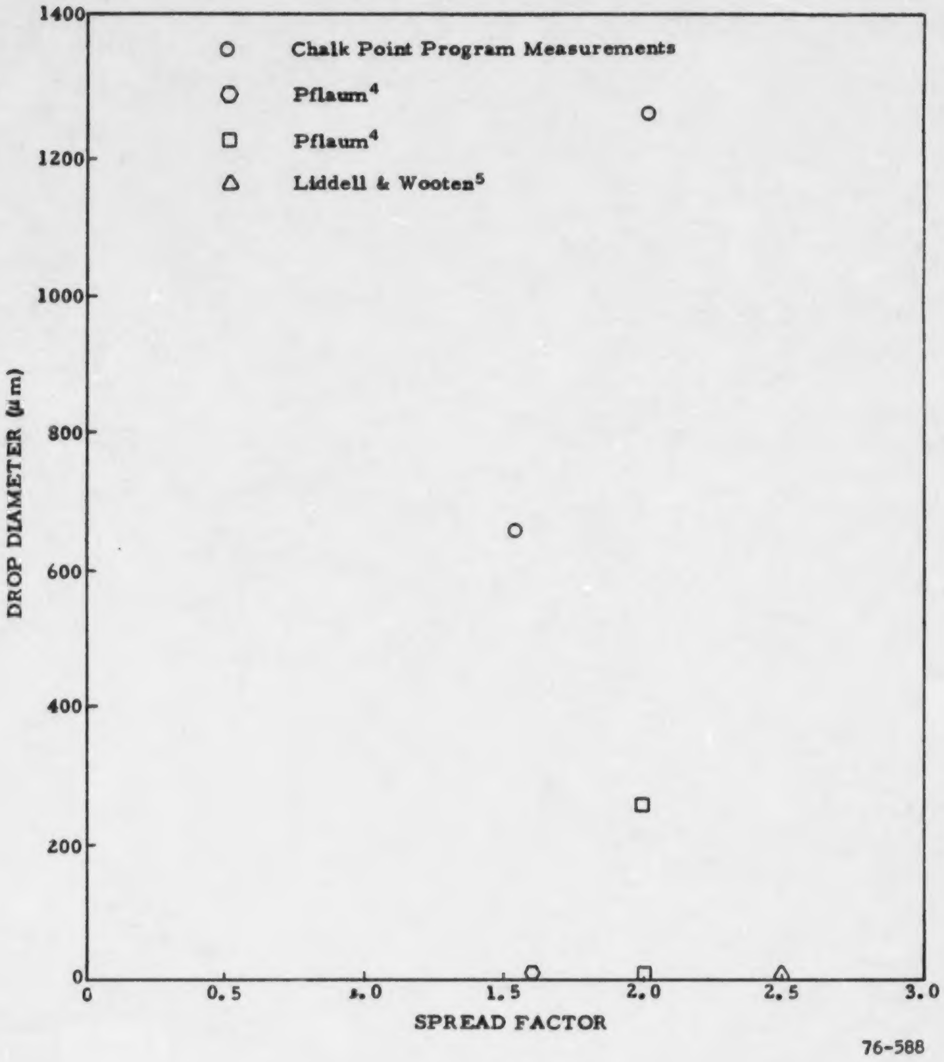

Figure 12. Spread Factors for Water Droplets on Gelatin

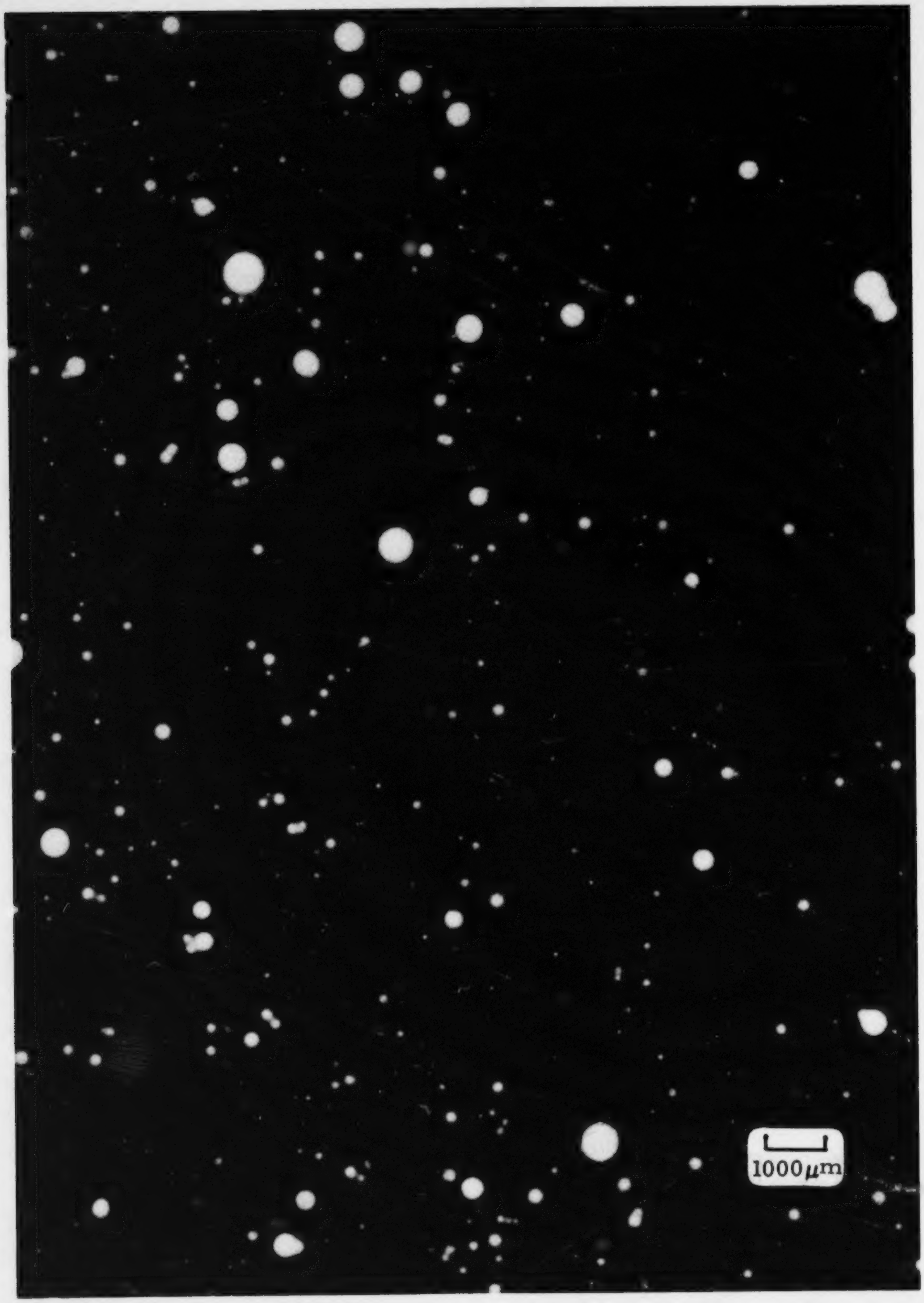

Figure 13. Typical Film Sampler Droplet Images, Traverse 16-69

A 20 μm diameter water droplet will reach evaporation equilibrium with the following salt concentrations[6]:

Relative Humidity	Approximate % NaCl
100	1
95	3
90	7
70	28
0	100

Larger droplets will contain slightly higher concentrations. Because the droplets collected by the film sampler are not small enough to have reached vaporization equilibrium for a sodium chloride solution, the concentration is below saturation. (Typical mass median diameters were on the order of 200 μm.) If a concentration of 5 percent is assumed, then 5 percent of the total water droplet mass collected by the film sampler can be taken as sodium chloride. The total water droplet masses collected during traverse samples are tabulated in Appendix C. For a typical 5 second plume traverse, the effective sample volume was approximately 75 ℓ. For a sample totaling 100 μg of water with 5 percent salt, the salt concentration in the plume will be on the order of 65 $\mu g/m^3$. Typical concentrations of 40 $\mu g/m^3$ were measured by ESC at the tower exit.

Samples for sodium chloride were also collected in the size range less than 30 μm diameter with the cascade impactor sampler. In most cases, salt was not detectable in concentrations higher than the minimum sensitivity of the IEXE method used for analysis, see Appendix E. The threshold sensitivity was approximately 35 ng/sample (250 ng/cm^2) for sodium or 89 ng for sodium chloride. (Each ng of sodium is equivalent to 2.52 ng of sodium chloride.) Each sample represents a sample volume of approximately 0.5ℓ/sec. (One quarter of the total sample flow rate of 2ℓ/sec flows through each of the four orifices.) The minimum detectable threshold of sodium chloride for a single 5-second pass through the plume is, therefore, approximately 36 $\mu g/m^3$. The detection limit is reduced if multiple traverses are sampled through the same impactor.

The largest sodium sample detected with the impactors was a two-traverse sample (traverses 15-8 and 15-9 on June 23, 1976). The traverses were made directly over the top of the tower on a calm high humidity day during which the large visible plume rose to approximately 610 m (2000 ft) almost straight up. Traverse altitudes were at 305 m (1000 ft) and 274 m (900 ft) msl (183 and 152 m above the top of the tower). The analysis indicated the following concentrations:

Particle Size (μm dia.)	NaCl Concentration (ng/ℓ)
15-30	$\leq 12^*$
3-15	$\leq 12^*$
0.4-3	15 ± 9
$<$ 0.4	9 ± 4
TOTAL	≤ 48

* Sensitivity Limit

These results imply that the maximum concentration of sodium chloride in particles smaller than 30 μm is approximately 48 ng/ℓ or less. The film sampler for these same passes collected a total droplet mass of 420 μg. If the droplets were 5 percent salt, the plume concentration would be approximately 100 ng/ℓ. A histogram of the size distribution from the film sampler for these two passes is shown in Figure 14.

4.2.1 Droplet Size Distributions

Physical size and concentration of drift droplets were also measured with the PMS optical probes. It is assumed that all drift droplets contain sodium chloride so that size distributions measured with the PMS system and the Chemical Film Sampler should agree.

A comparison of actual measurements indicates that the film sampler tends to give higher mass median diameters (MMD) than the PMS probe, see Table 3.

Examination of the complete size distributions indicates that the MMD is heavily weighted by a few large droplets on the film (larger than 400 μm diameter). The PMS sensor is limited to droplets smaller than 300 μm, and the sampling volume is lowest for the largest droplets. The effective sampling volume for the film sampler is approximately

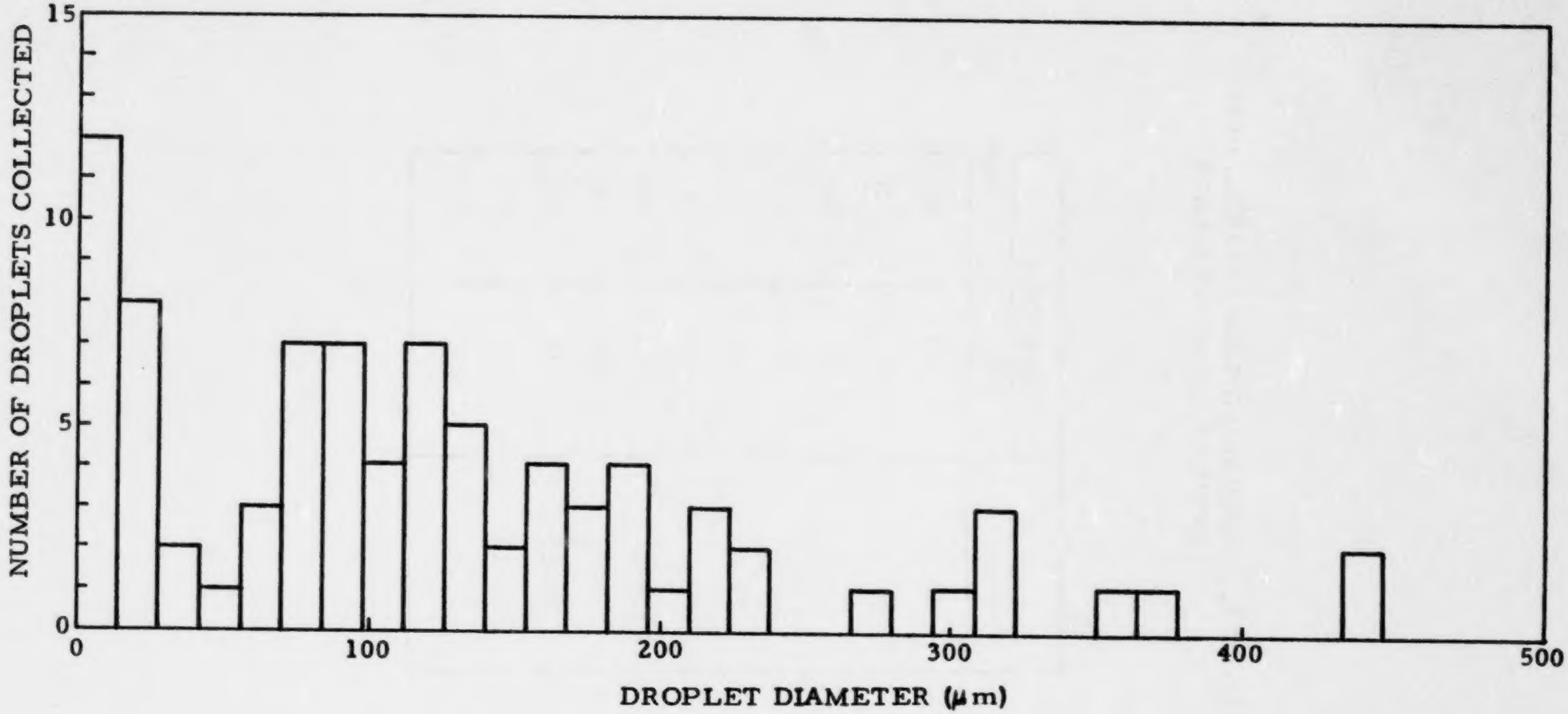

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Figure 14. Histogram of Droplets Collected by Film Sampler (Traverse 15-8, 15-9)

TABLE 3. COMPARISON OF TYPICAL DRIFT DROPLET MEASUREMENTS

Traverse Number	MMD (μm)	
	PMS	Film
15-2	80	329
15-3	80	371
15-4	40	315
15-5	280	329
15-6	200	343
15-7	80	287
15-8	140	399
15-10	100	231
15-11	40	231
15-12	80	343
15-13	280	273

5000 times larger than for the PMS sensor. The probability of the PMS sensor seeing the largest droplets is, therefore, also much lower than for the film sampler. The number mean diameters for both samplers are on the order of 50 μm diameter.

4.2.2 Plume Cross Section

The basic approach to measuring the cross sections of salt drift plumes is similar to that used for the vapor plumes. The primary method of sensing the sodium chloride is the MRI Chemical Film Sampler; the secondary method is the PMS sensor. Using the film sampler, upper and lower bounds of the salt drift plume can be determined but not the horizontal width, because the sample is integrated over the length of the plume traverse. Because the droplets in the drift plume are larger than in the visible plume, the lateral diffusion of the plume will tend to be equal to or less than for the visible plume. Extremities of droplet sedimentation rates can be made from droplet size distributions measured with the film samplers. Figure 15 shows settling rates for water droplets. The salt drift plume cross section can then be estimated analytically by using data input from wind speed measurements, visible dispersion rates, and size distributions of droplets containing sodium chloride.

4.2.3 Plume Rise

Salt drift plume rise can be measured from chemical film samples taken over the range of altitudes that encompass the plume extremities. Because large drift droplets can fall to the ground in close proximity to the cooling tower, sampling traverses were made as close to the tower as safety permitted. Traverses were made within approximately 80 meters of the tower and 80 meters from the ground. Results of the sodium chloride measurements are given in Appendix C.

4.2.4 Integrated Liquid Water Drift

Liquid water content in the drift plume was also determined by both the PMS droplet spectrometers and the Chemical Film Sampler. The integrated volume of all the water droplets is determined from the size distributions and concentrations measured by the PMS sensors. The PMS method provides real-time half second averages of the water content, which results are tabulated in Volume 1 and plotted in Volume 4 of this report. The total mass of liquid water sampled by the film sampler is double the mass median diameter. The mass median diameters are tabulated in Appendix C.

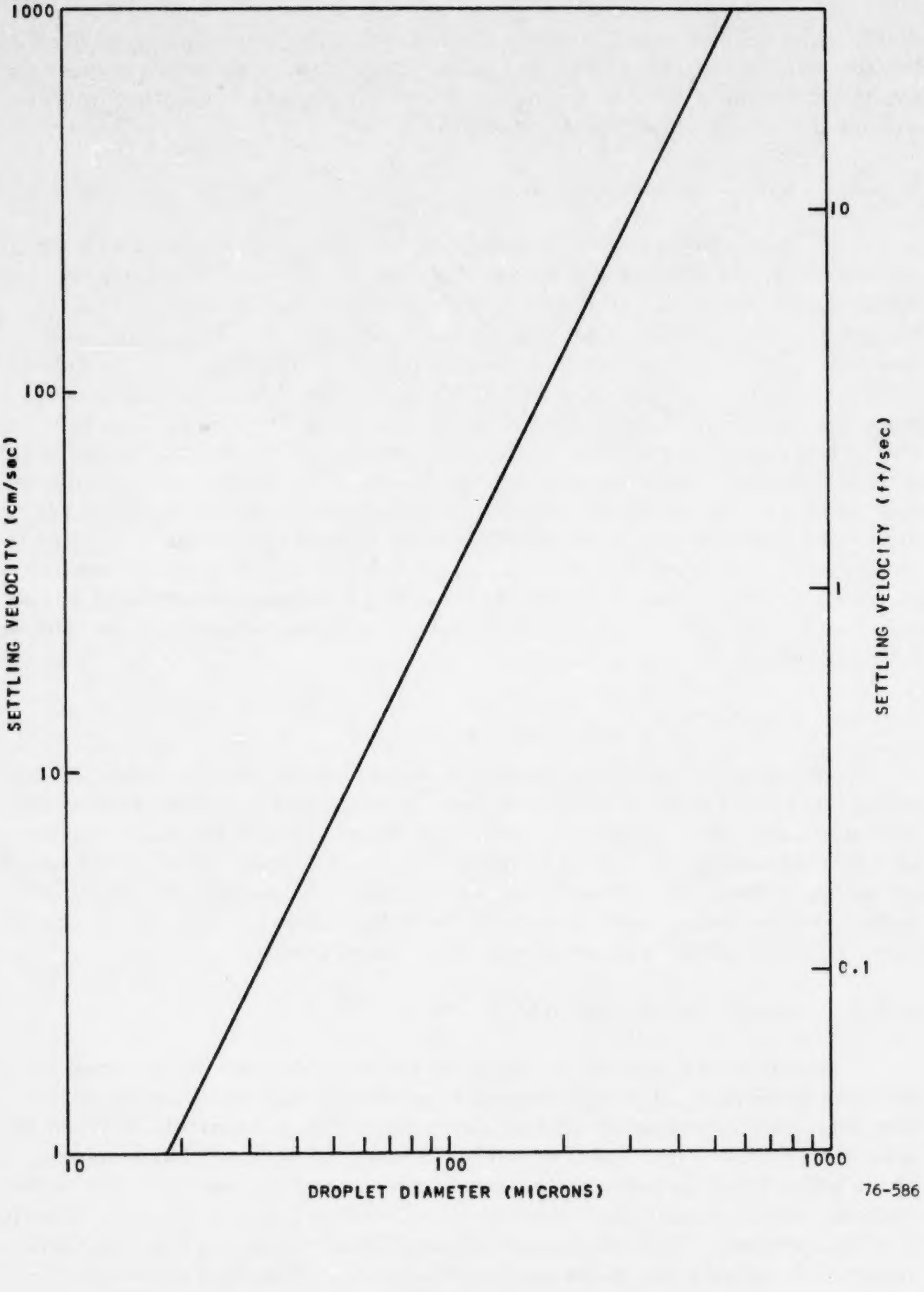

Figure 15. Nominal Settling Rate of Water Droplets in Air

4.3 Interaction of Boiler and Cooling Tower Plumes

On most of the test days there was little if any mixing or interaction between the boiler and cooling tower plumes. Some plume mixing was observed on three test days: December 17 (Test 6,), December 19 (Test 7), and June 23 (Test 15). Photographs showing the plume mixing for Tests 6 and 15 are included in Appendix D. Two specific measurements were made in the mixing zone: sulfur dioxide concentration and sulfuric acid mist concentration.

4.3.1 Sulfur Dioxide Concentration

Sulfur dioxide concentrations were measured with a Theta electrochemical cell sensor. Results are given in the data tables in Volume 2 and are presented in graphical form as a function of time in Volume 3. The SO_2 sensor provided half-second average concentrations. Measurements beyond the edge of the plumes provided a baseline of ambient SO_2 concentrations. Baselines were generally less than 0.01 ppm, while typical smoke plumes ranged from 1 to 12 ppm.

The boiler exhaust system includes a wet venturi scrubber that adds a significant amount of water to the boiler plume in the form of both droplets and vapor. Temperatures and concentrations of water and boiler plume constituents are much higher within the plume prior to dispersion. Reaction rates are, therefore, likely to be much higher in the exhaust system than at any time after emission from the stack. It, therefore, appears that reactions involving SO_2 and water would occur within the boiler plume prior to mixing with the cooling tower plume. Since the boiler plume already contains sufficient water for the chemical reactions to occur, the addition of more water from the cooling tower plume during plume mixing is likely to have only a small effect. There is insufficient experimental evidence to indicate any chemical reactions within the interaction zone of the boiler and cooling tower plumes.

4.3.2 Sulfuric Acid Mist Concentration

Sulfuric acid concentrations were measured by two methods: the Chemical Film Sampler for droplets larger than approximately 30 μm diameter and the cascade impactor for droplets smaller than 30 μm. In both cases the droplet collection surface was treated with quinine. The quinine reacts with sulfuric acid to produce quinine sulfate. The quinine sulfate is more stable than sulfuric acid so the sample can be stored. It is also fluorescent so that its presence can be detected by illumination with ultraviolet light.

Figure 16 shows an impactor stage that exhibited fluorescence using ultraviolet illumination. Figure 17 shows the same sample using white illumination. The increased brightness of the sample spots under ultraviolet illumination is due to sample fluorescence (only the top half was coated with quinine).

Limited fluorescence was observed on some samples from both the cascade impactor and the Chemical Film Sampler, but usually not enough to make quantitative measurements.

Preliminary laboratory tests have shown that the quinine fluorescence method is sufficient to detect less than 1 $\mu\ell$ of 0.02 N sulfuric acid (equivalent to approximately 1 μg of H_2SO_4). A single pass through a plume 100 meters wide typically provides a sample volume of approximately 0.25 m^3. The overall sensitivity under these conditions is, therefore, approximately 4 $\mu g/m^3$. The cascade impactor limit of sensitivity is approximately 150 $\mu g/m^3$ because of its lower sampling rate (approximately 2 ℓ/sec).

The highest concentrations of sulfuric acid were detected in the boiler plume before mixing with the cooling tower plume (using the impactor sampler). The quantity, however, was near the threshold sensitivity of the analytical method (on the order of 150 $\mu g/m^3$). Because of plume diffusion and low reaction rates in the interaction zone, concentrations were lower in the interaction zone measurements.

4.4 Potential Aircraft Hazards

Because of the large quantities of heat and moisture added to the atmosphere by a large cooling tower, some effect on the surrounding environment is unavoidable. One of the effects is inadvertent weather modification. The rising plume induces turbulence and mixing with the atmosphere. As the water-saturated air cools, its temperature drops below the dew point, and water condensation droplets are produced as a visible plume. If the humidity of the surrounding ambient air is near 100 percent, the visible plume can grow to large dimensions. Potential hazards to aircraft include visibility, turbulence, and icing.

A moderate range of ambient meteorological conditions exist at Chalk Point. Surface level temperatures range from occasional highs of 38°C in summer to occasional lows of -15°C in winter. Temperatures below 0°C occur for about 650 hours per year. Relative humidity ranges from near 30 percent to 100 percent. The season of lowest relative humidity tends to be during winter and early spring when the average is near 60 percent. The season of maximum relative humidity

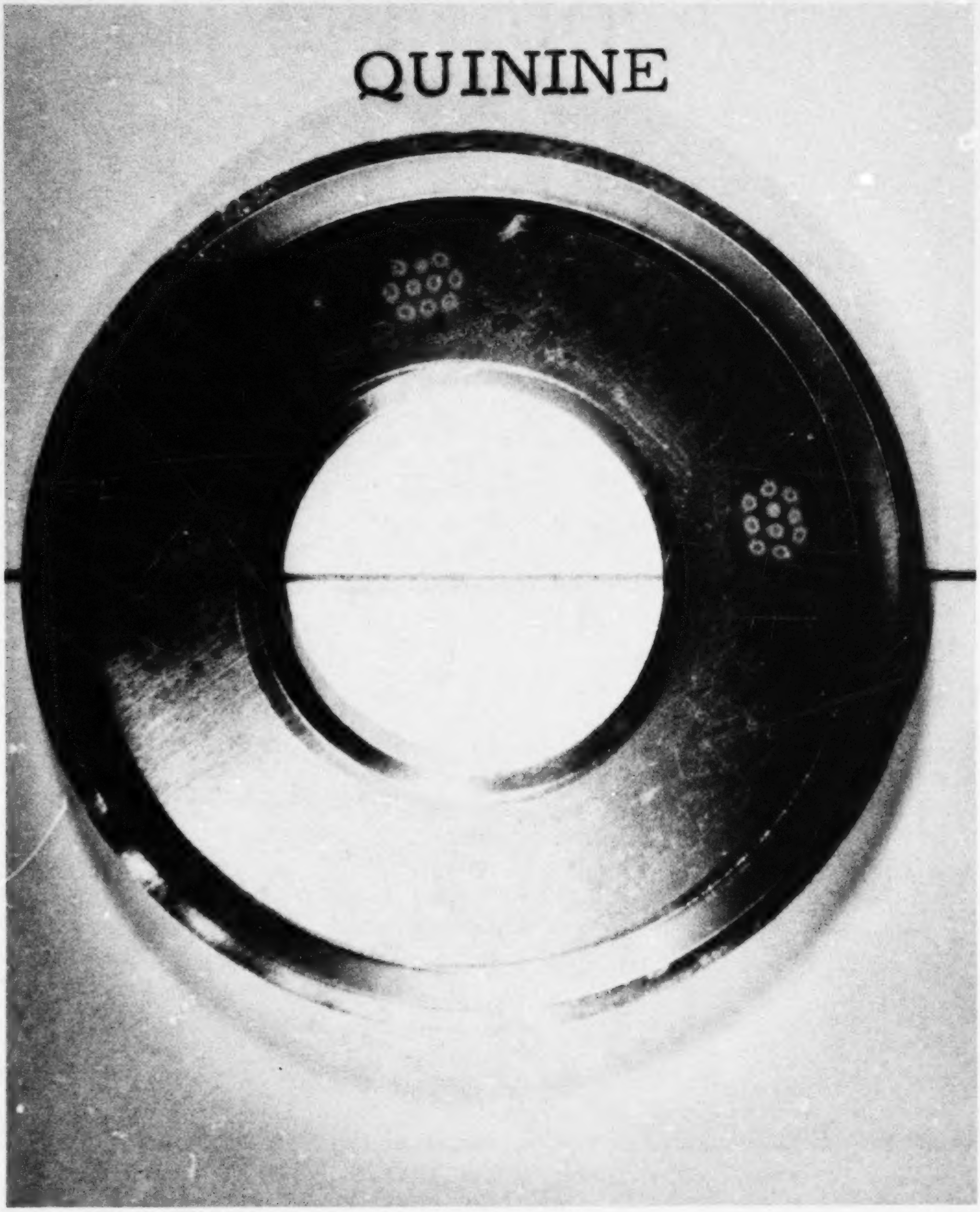

Figure 16. Fluorescent Sample on Impactor Stage Under Ultraviolet Light

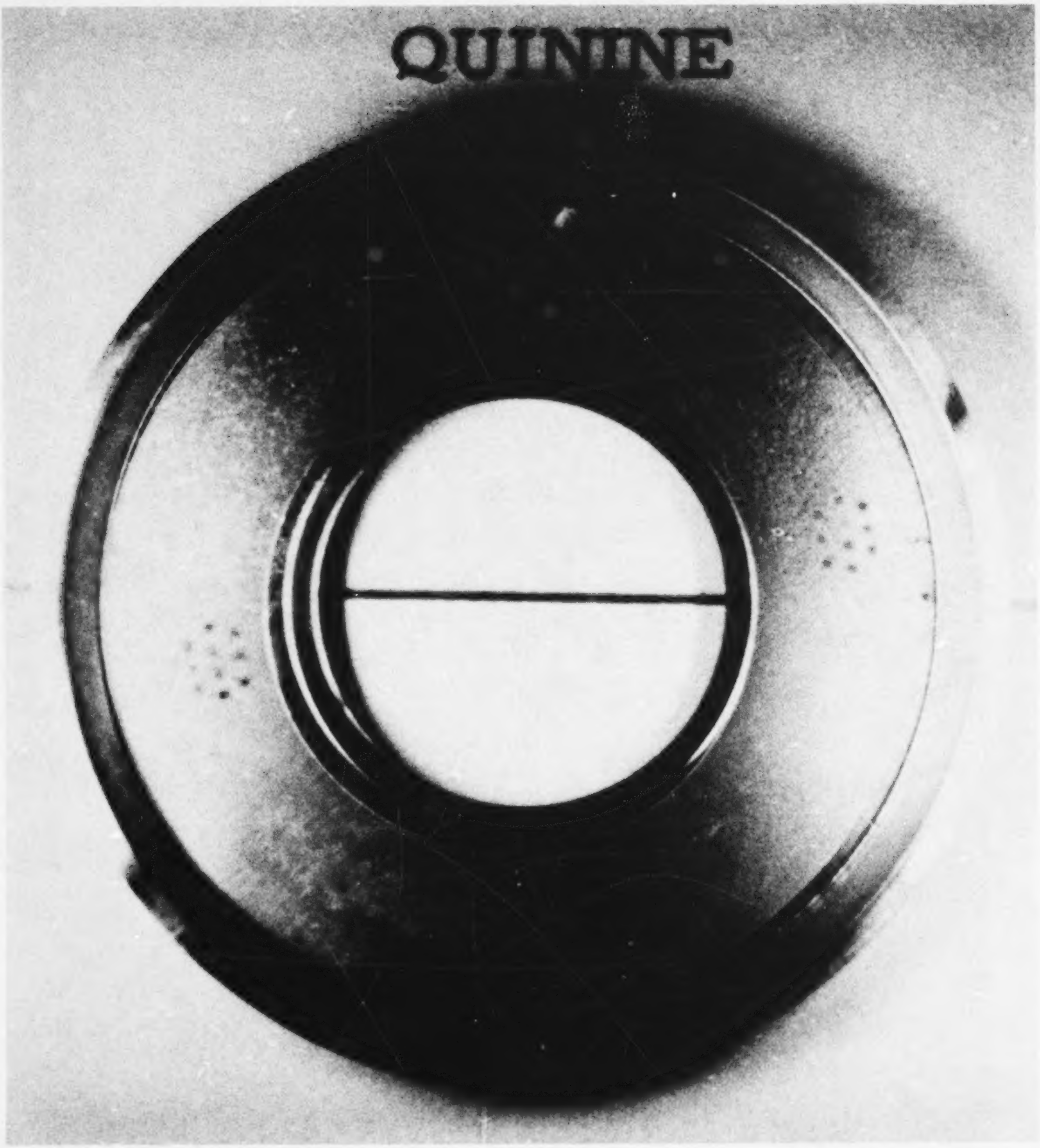

Figure 17. Fluorescent Sample on Impactor Stage Under White Light

occurs in late summer and early fall when the average is near 75 percent.

4.4.1 Visibility Hazards

The addition of large quantities of moisture by the cooling tower results in a visible plume which will reduce air-to-air and air-to-ground visibility in the immediate area. As the ambient temperature decreases, the downwind extent of the plume will tend to increase, enlarging the area of restricted visibility. For an average liquid water content (LWC) of 0.05 gm/m^3 and a droplet diameter of 10 μm, visibility in the plume should be restricted to approximately 400 m. If the LWC is less or the mean droplet diameter is greater, the visibility in the plume will be greater[7]. Because of the limited size of visible plumes, visibility hazards are not expected to be serious hazards to aircraft. Under weather conditions that produce large persistent plumes, natural clouds or fog will also normally exist and visibility will already be limited even without the plume. Thus, the plume would not substantially reduce visibility conditions. The only exception is under very cold, snow-out conditions, a rarity at Chalk Point.

4.4.2 Icing Hazards

During the winter season, aircraft icing in the visible plume is a possibility. The conditions necessary for the formation of structural icing, i.e., visible liquid moisture, free-air temperature at or below freezing, and the aircraft-surface temperature colder than 0°C, will certainly exist at times. The rate of accretion of in-cloud ice (rime) on the structure of an aircraft is a function of, among other things, the aircraft airspeed, the liquid water content of the cloud or visible plume, the size of the water droplets, and the collection efficiency of the structure. For a given aircraft and airspeed, the accretion rate will increase with either higher LWC or larger droplet sizes. If a high LWC of 1.0 gm/m^3 and a mean droplet diameter of 20 μm is assumed, an aircraft flying at 100 mph could accrete rime at a rate of 0.032 mm/sec. If such an aircraft flew in this heavy plume for ten miles, it would be possible to collect 11.5 mm or 0.45 inches of rime on some of the sharpest leading edges of the plane.[8]

The largest drop sizes and highest LWC's found in vertical plumes could possibly result in glaze in some circumstances; however, it would be difficult to remain in the plume long enough to collect more than a trace of ice. Icing hazards are, therefore, considered insignificant compared to natural icing hazards under these conditions.

4.4.3 Turbulence Hazards

During the sampling program, nearly every penetration of a plume resulted in at least moderate turbulence with only a few passes through visible plumes not recording at least 4.0 R-units.* In most cases, values above 5.0 were recorded. At least eleven penetrations resulted in severe (>7.0 R-units) turbulence being recorded. While most of these cases occurred in a vertical plume, several cases of severe turbulence did occur in bent over plumes.

This sampling program was conducted during a period when plume temperature seldom exceeded ambient by more than 3°C. During the cold seasons with greater temperature differences between the tower effluent and the ambient air, more plume buoyancy will occur, and as a result, more turbulence can be expected by aircraft penetrating plumes at that time. This conclusion is qualitatively apparent. However, to arrive at quantitative estimates for the vertical velocities resulting from buoyancy (and hence, a quantitative estimate of the turbulence to be expected), additional modeling is required.

Anyone penetrating a cooling tower plume in an aircraft should anticipate encountering severe turbulence of a few seconds duration. The interior of a plume appears to be an ever-changing pattern of eddies, and it is unlikely that any two penetrations will be exactly the same. This fact in itself could be a significant hazard. A pilot who has made one or two, or several passes, through a plume with no more than light-to-moderate turbulence should not forget that the potential for very severe turbulence is always there. Because the duration of the turbulence is so short, and the most turbulent portions of the plume are usually visible, turbulence is not likely to be a serious hazard. However, it is possible that an unattentive pilot violating visual flying rules could temporarily lose control of his aircraft.

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*Turbulence is due to fluctuations in air speed. These fluctuations are measured in R-units, which have the dimensions of $cm^{2/3} sec^{-1}$. Light turbulence is 1-2 R-units, moderate 2-5, severe 5-10, extreme >10.

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Appendix A

DESCRIPTION OF INSTRUMENTATION

1. Cloud Particle Spectrometer, PMS OAP-200X

The Cloud Particle Spectrometer (CPS) counts and sizes particles with diameters from 20 μm to 300 μm by imaging the shadow of each particle on an array of photodiodes. A helium-neon laser (6328 Å) is used with condensing and imaging optics to focus the shadow of a particle lying within the sample volume. An array of 24 photodiode elements spaced 200 microns apart is used to size the shadow. Photodetectors and logic circuitry convert the signal from the photodiodes into a count tagged with one of the fifteen size channel numbers.

A summary of the Cloud Particle Spectrometer characteristics is given in the following table.

TABLE A-1. CLOUD PARTICLE SPECTROMETER CHARACTERISTICS

Number of array elements	24
Number of size channels	15
Size range	20-300 microns
Maximum particle velocity	250 knots
Maximum aperture	6.5 cm
Power	115 V, 50-400 or 60 Hz, 60 Watts De-ice: 28 VDC, 70 Watts
Dimensions	Cylinder: 28" L, 6 1/2" Diameter Optical Extensions (2): 10" L, 1" Diameter
Weight	28 lbs.
Environmental	Temperature: -60°C to +50°C Humidity: 10% to 100% Altitude: 0-40,000 ft. MSL

2. Axial Scattering Spectrometer, PMS Model ASSP-100

The Axially Scattering Spectrometer Probe (ASP) is used to count and size particles with diameters from 2 to 30 μm. This spectrometer probe includes all electronics and optics necessary for particle size determination. An external probe houses the laser, condensing and imaging optics, and photodetector modules. The signal conditioners, pulse height detector, and power supplies necessary for independent operations are housed in a separate enclosure inside the aircraft cabin. The spectrometer probe is capable of sizing particles over 15 intervals. The sensing element is built into an airfoil shaped boom, 24 inches long. The optics, laser, and scattering detector electronics are housed within the airfoil which can be mounted to the aircraft at an established hard-point. Particles are sized within an isokinetic annulus of approximately 1.5 inches diameter. The probe's laser illuminates particles passing through the annulus, and particles are viewed over the central few millimeters of the optical path length. The system is capable of resolving particles as small as 1 micron at 250 knots airspeed.

The characteristics of the Axially Scattering Spectrometer are summarized in the following table.

TABLE A-2. AXIALLY SCATTERING SPECTROMETER PROBE CHARACTERISTICS

Number of size channels	15
Size range	2-30 microns
Size resolution	2 microns
Maximum particle rate	100 KHz
Coincidence errors	Less than 1% with concentrations of 10 cm^{-3}
Maximum particle velocity	125 meters sec^{-1}
Power	115 V, 60 Hz, 1.0 A plus required de-ice power (300 W using 28 V heaters)
Environmental	Temperature: -40°C to +40°C Altitude: 0-40,000 ft. MSL
Mechanical	Probe: 24" long airfoil
Weight	Probe: Approximately 6 lbs.

3. Buffer Memory System and Readout, PMS

The Buffer Memory System (BMS) accepts signals from the ASP and CPS Spectrometers and from the Flight Condition Sensors, converts them into 4-digit BCD numbers and transfers the numbers to magnetic tape. A total of 64 4-digit words are available. Thirty are used to convert serial binary data from the spectrometers into accumulated counts in the 30 size classes. One word is used as an incremental clock, and 12 are available to convert 0-10 volt signals from other instruments into BCD numbers with a resolution of one millivolt. Two other channels are used for system monitoring, and the rest are spares.

Each half-second, the Buffer Memory transfers the contents of the 64 words onto digital magnetic tape. An output shift register is used to group the data into 8-bit segments.

The Buffer Memory has a visual display and selector dials which allow the contents of any one of the 64 words to be monitored. The BMS specifications are given in Table A-3; channel assignments are given in Table A-4.

TABLE A-3. BUFFER MEMORY SYSTEM, SPECIFICATIONS

Number of addresses	64
Number of probe inputs	Up to three
Addresses per probe	15
Number of bits per address (word)	16
Input interface requirements	5 line binary encoded particle size plus strobe (positive logic minimum 100 n sec strobe pulse width)
Analog inputs	12 channels, 0-10 VDC
Output interface requirements	64 serial or parallel words of four BCD characters each
Internal BCD Clock	One of the 64 words shall derive from a 4-digit BCD counter which accumulates pulses from a 1 Hz clock, having a stability of 1 part in 10^6
Power	115 V, 2 A, 55-400 Hz, 100-200 W
Dimensions	19" W x 17" L x 5" H not including connectors. Standard rack mount

Probe 1, ASP		
Channel No.	**Data Recorded**	**Range**
1	(Spare)	-
2	0-2 µm Dia.	0 to 9999 Counts
3	2-4 "	"
4	4-6 "	"
5	6-8 "	"
6	8-10 "	"
7	10-12 "	"
8	12-14 "	"
9	14-16 "	"
10	16-18 "	"
11	18-20 "	"
12	20-22 "	"
13	22-24 "	"
14	24-26 "	"
15	26-28 "	"
16	28-30 "	"

	Probe 3, CPS	
Channel No.	**Data Recorded**	**Range**
33	BMS Time	
34	0-20 µm Dia.	0 to 9999 Counts
35	20-40 "	"
36	40-60 "	"
37	60-80 "	"
38	80-100 "	"
39	100-120 "	"
40	120-140 "	"
41	140-160 "	"
42	160-180 "	"
43	180-200 "	"
44	200-220 "	"
45	220-240 "	"
46	240-260 "	"
47	260-280 "	"
48	280-300 "	"

Probe 2, Spare		
Channel No.	**Data Recorded**	**Range**
17	Impactor Status	*
18	(Spare)	-
19	"	-
20	"	-
21	"	-
22	"	-
23	"	-
24	"	-
25	"	-
26	"	-
27	"	-
28	"	-
29	"	-
30	"	-
31	"	-
32	"	-

Probe 4, Analog Data		
Channel No.	**Data Recorded**	**Range**
49	(Spare)	-
50	Turbulence	0-10 R units
51	ΔP, 0-0.7 PSID	0-0.7 PSID
52	Slow Temp	-30° to + 50°
53	Fast Temp	Variable
54	(Spare)	-
55	Dew Point	0° to 120°F
56	Abs. Pressure	0 to 15 PSIA
57	Nephelometer	0 to 100 x m^{-4} m^{-1}
58	SO_2	0 to 1 PPM
59	(Spare)	-
60	**	**
61	(Spare)	-
62	ASP Total	0 to 9999 Counts
63	(Spare)	-
64	CPS Total	0 to 9999 Counts

* Channel 17 includes:
Impactor No. 1 on : 1
Impactor No. 2 on : 2
Impactor No. 3 on : 4
Impactor No. 4 on : 8

** Channel 60 includes:
Event Marker: 1-9 (1st digit)
Nephelometer Range: 1, 2, 3 (2nd digit)
Film Transport: 4 (2nd digit)
Day of Month: (3rd and 4th digit)

TABLE A-4. BMS DATA CHANNEL ASSIGNMENT

4. Incremental Magnetic Tape Recorder, Kennedy Model 1600/360

A Kennedy Tape Recorder is used to record the contents of the Buffer Memory each half-second on a 9-track computer compatible magnetic tape. The recorder generates the necessary record and file marks, including standard check characters, that allow the tape to be processed directly onto IBM 360 or similar computers. Specifications are given in Table A-5.

TABLE A-5. RECORDER SPECIFICATIONS

Type	Incremental, 9-track
Write-Rate	0-4000 bits/sec.
Density	800 bpi
Reel size	10 1/2 in. (2400 ft. of 1.5 mil tape)
Recording time	Over 20 hrs.
Size	19 x 12 1/2 x 10
Weight	45 lbs.
Temperature range	0°C to 50°C
Altitude range	up to 20,000 ft.

5. Dew Point Hygrometer, EG&G Model 137, Vapormate II

The dew point sensor uses a gold-plated mirror which is chilled by a thermoelectric cooler. Light from a solid state source is reflected by the mirror to a photodetector. As condensation forms on the mirror, the light is scattered and the intensity at the detector is reduced. The reduced intensity causes a controller to increase the mirror temperature, thus reducing condensation. The proportional controller maintains a constant dew layer thickness on the mirror surface so that it is in equilibrium with the partial pressure of the water vapor in the air sample. At this time the temperature of the mirror is the dew point temperature. The mirror temperature is measured by a thermistor embedded inside the mirror. At temperatures below 0° C, the condensate on the mirror is in the form of ice, and therefore, the temperature of the mirror surface is the frost point temperature.

DEW POINT SENSOR SPECIFICATIONS

Model	137
Range	-70°F to +160°F
Dew point depression	> 65°F
Accuracy	± 1.4°F
Response	4°F per second
Dew point repeatability	0.1°F
Output signal	0-50 mvdc
Weight	15 lbs.

6. Fast Response Temperature Sensor, TSI Model 1044

The model 1044 temperature sensor is manufactured by Thermo Systems, Inc. It uses a fine tungsten wire resistive sensor, 5 μm diameter, to provide fast response temperature measurements. The air sample is aspirated past the wire through a choked orifice to maintain constant air flow.

TSI TEMPERATURE SENSOR SPECIFICATIONS

Temperature range	-30° C to $+50^\circ$ C
Output voltage	0 to 5 volts DC
Accuracy	± 2° C
Nominal sensor resistance	80 ohms
Aspiration rate	200 cm^3/min.
Probe length	10.25 in.
Response	1 KHz

7. Vortex Temperature Sensor, MRI Model 800

The vortex temperature sensor uses a linearized thermistor network to measure ambient air temperature. The thermistor is mounted in a vortex sampling housing. The housing eliminates errors due to radiation and air friction during sampling. The voltage across the thermistor bridge circuit is amplified to provide an output signal of 0 to 5 volts DC.

VORTEX TEMPERATURE SENSOR SPECIFICATIONS

Temperature range	-30° to $+50^\circ$C
Output voltage	0 to 5 volts DC
Accuracy	± 1°C

8. Universal Indicated Turbulence System, (UITS), MRI Model 1120

The UITS system is used to determine both airspeed and turbulence.

Airspeed

Airspeed is sensed by a pitot static probe. The differential pressure of the probe is measured with a 0 to 0.7 PSI differential pressure transducer that provides an output of 0 to 5 volts DC. The output voltage is recorded on the magnetic data tape, and airspeed is calculated during data reduction by a computer program. The accuracy of the system is ± 5 mph.

Turbulence

Turbulence measurements are also made with the pitot-static sensor by measuring the variations of airspeed that are caused by turbulence. The sensing is done along the longitudinal axis of the aircraft (directly relatable to variations along other axes). The variations in airspeed result in pressure variation in the pitot static system. These pressure fluctuations are sensed by the differential pressure transducer. The outputs of the transducer are voltages that represent the mean airspeed and the variation in airspeed. A miniature computer processes the output voltages and automatically computes the turbulence intensity. The computer provides an output of 0-5 volts DC that is proportional to atmospheric turbulence intensity over the range of 0 to 10 R units. The turbulence measurements are independent of aircraft size, speed, or response characteristics of the aircraft. The sensor includes a Validyne variable reluctance transducer and a carrier demodulator to generate a voltage analog of differential pressure. The transducer pressure range is 0 to 7 psi, with a linearity of ± 1/2 percent full scale and a frequency response of 0 to 1000 Hz. (See table on following page.)

UITS SPECIFICATIONS

Sensor output	0 to 5 volts DC with superimposed AC
System gain	Corresponding to $R = 10\ cm^{2/3}/sec.$
Band pass	2-50 Hz
Averaging time	3 ± 0.5 sec.
Accuracy	± 10% of theoretical
Repeatability	±2% (40° to 100° F) ±5% (-40° to 130° F)
Drift	1% in 8 hrs.
Weight	10 lbs.

9. Altitude Sensor, Validyne P-24 Pressure Transducer

Static pressure is measured by a Validyne P-24 absolute pressure transducer. Altitude is calculated using the following formula

$$\text{Altitude (ft)} = 145,365.7 \left[1 - \left(\frac{\text{Pressure Voltage}}{4.8986} \right)^{0.19023} \right]$$

The pressure altitude measurement is corrected for variations in barometric pressure and temperature. The transducer provides an output of 0 to 5 volts DC for the pressure range of 0 to 15 PSIA. Altitude measurements have an accuracy of ± 20 ft.

10. Nephelometer, MRI Model 1550

The integrating nephelometer measures the scattering coefficient of water droplets or particles in the air volume being sampled. The scattering coefficient is inversely proportional to the visability range and proportional to the mass concentration of the aerosol. The instrument primarily measures particles in the 0.1 to 1.0 micron diameter size range. An air sample is continuously drawn through a chamber where it is illuminated by a pulsed flash lamp. The scattered light is detected by a photomultiplier tube looking at the illuminated air sample. The signal produced is compared and averaged with a reference voltage produced by a phototube looking at the flash lamp. This signal is amplified to give an output of 0 to 5 VDC for 0 to 100 x 10^{-4} m^{-1} or 0 to 10 x 10^{-4} m^{-1} (range A). The system accuracy is ±10 percent.

MODEL 1550 NEPHELOMETER SPECIFICATIONS

Sensitivity	Scattering coefficient: 0.1 to 100 x 10^{-4} m^{-1} Local visual distance: to 0.3 mi. Mass (approx.): 0 to 3800 μgm/m
System accuracy	±10% of scale
Output voltage	0 to 5 volts DC
Output impedance	5 K ohms
Averaging time (selectable)	2 to 200 sec.
Air sampling rate	Approx. 5 cfm
Weight	41 lbs.
Power requirements	120 VAC, 60 H, 70 watts
Temperature range	0 to 130° F
Altitude	0 to 14,000 ft.

11. SO_2 Sensor, Theta Systems Model LS 400 AC

The SO_2 Sensor is an electrochemical transducer. The principle of operation is based on the combined use of a semipermeable membrane and the selective redox reactions within a sealed transducer cell. The membrane selectively passes SO_2 into the cell where it reacts chemically to produce an electrical current. The current is directly proportional to the SO_2 concentration. The permeation and reaction rates are controlled by the concentration of SO_2 in the sample.

SO_2 SENSOR SPECIFICATIONS

Ranges	0-1 ppm and 0-10 ppm
Linearity	2% full scale
Accuracy	±2% full scale
Repeatability	±1% full scale
Operating temperature range	40° F to 100° F range
Weight	8 lbs.
Response time T_{90}	<10 sec.
Recorder output	0-5 volt

12. Chemical Film Sampler, MRI Model 815

The film sampler includes a chemically treated gelatin-coated acetate film and a film transport mechanism enclosed within an airfoil shaped wingpod. Drift droplets are impacted on the film collection surface as the aircraft flies through a plume. The film is advanced to a new frame on command of the operator. The chemical treatment of the film depends on the sample material to be detected. For sulfuric acid, the film includes a coating of quinine. The quinine reacts with sulfuric acid to produce quinine acid sulfate. The sulfate fluoresces when illuminated with ultraviolet light, and the fluorescence intensity is a function of the quantity of sulfate present. For the concentration ranges used in the film sampler, the intensity is directly proportional to the sulfate concentration.

For sodium chloride measurements, salt deposits on the film are converted to silver chloride, then reduced to silver. The silver leaves a permanent image on the film. The quantity of silver is proportional to the original amount of sodium chloride.

For the Chalk Point program, half of the film was treated for detection of sulfuric acid and half for detection of sodium chloride. The collection surface area of 49 cm^2 was, therefore, equally divided for the two detection systems. Sulfuric acid concentrations were measured with a specialized fluorimeter. Size distributions and concentrations of water droplets that contained salt were measured using a Quantimet automatic image analyzer.

CHEMICAL FILM SAMPLER SPECIFICATIONS

Sample collection area	70 x 70 mm (49 cm^2)
Sampling rate @ 100 m/sec	49 x $10^4 cm^3/sec$
Collection efficiency (for droplet density of 1 @ 30 m/sec)	80%, 20 μm dia. 50%, 11 μm dia. 10%, 7 μm dia.
Film capacity	100 ft. (300 frames)

13. Cascade Inertial Impactor, MRI Model 1502AC

The MRI cascade impactor draws an aerosol sample through a series of jet orifices. Droplets or particles passing through the orifices are impacted on a collection surface that is positioned directly beneath the orifice. Each successive stage of the impactor contains smaller orifices and closer collection surface spacing than the previous stage. The final stage is a filter that collects all particles that were too small to be collected by inertial impaction on any of the stages. The impactor effectively separates the sample into a series of selectable size ranges. The sample for each size range can then be analyzed as a separate sample.

For aircraft use, four impactor samplers are mounted in a wingpod and each sampler is operated independently so that four sets of samples can be collected.

CASCADE IMPACTOR SPECIFICATIONS

Sample flow rate	2 CFM during Dec. 1975 tests 4.5 CFM during June 1976 tests
Cut-off diameters (D_{50})	Stage 1 = 15 μm Stage 2 = 3 μm Stage 3 = 0.4 μm Filter < 0.4 μm
Collection substrate	Mylar, 1 mil
Substrate coating	Gelatin or gelatin impregnated with detection chemicals

14. Water Vapor Sensor, Tarantula, Model Lyman-Alpha

The Lyman-Alpha sensor consists of a light source, a detector, and an output signal log amplifier. The light source produces the Lyman-Alpha hydrogen emission line, and the intensity is measured by the detector. When water vapor is present in the optical path, it absorbs part of the light, and the intensity at the detector is reduced. The reduction in intensity is a logarithmic function of water concentration; and by using a log amplifier, the instrument output voltage is made directly proportional to absolute water vapor content. The dew point was calculated from the water content measurements.

LYMAN-ALPHA SENSOR SPECIFICATIONS

Absorption line wavelength	121.6 nm
Sensitivity	0.1 gm/m^3
Accuracy	5% (1°C dew point)
Resolution	0.2%
Response time (10-90%)	0.01 sec.
Optical windows	Magnesium fluoride

Appendix B

SUMMARY OF PLUME TRAVERSES

Appendix B

SUMMARY OF PLUME TRAVERSES

Each aircraft flight for sampling the Chalk Point cooling tower plumes was assigned an MRI test number, and each traverse was given a traverse or "pass" number. All reported data are identified by the test and traverse numbers. A description of each traverse is provided in the tables of this appendix. A pass number beginning with "S" is used to identify vertical spirals. The spirals were used for measurement of temperature changes with altitude. During the June 1976 tests, a complete series of rawinsonde soundings were provided by the Applied Physics Laboratory of Johns Hopkins University so that aircraft spirals were generally not as essential.

Altitudes given are nominal readings from the aircraft altimeter. Exact altitudes are printed in the data tables in Volume 2. The pass end points identify specific landmarks on the ground. The aircraft flew a straight line path between the landmarks. All of the landmarks were located on an enlarged aerial photograph in order to determine the exact location of each flight path. Aircraft headings are given as the direction that the aircraft is flying relative to magnetic North (8° declination from true North). Magnetic north was determined from a plot plan of the Chalk Point power plant. The distances given are the distances from the center of the cooling tower to the aircraft flight path, perpendicular to the flight path. The accuracy of aircraft direction headings is estimated to be well within ± 10% and the path locations within ± 10%. The location information refers to the test plan. Section 0 is upwind of the cooling tower; 1 is downwind close to the cooling tower; 2 and 3 are further downwind, usually within or under the visible plume; 4 is beyond the end of the visible plume. The location description gives the approximate pass location relative to the visible plume length, L. The impactor column lists the impactor number used during a given pass. If the same number appears more than once for a given test flight, the impactor was used on more than one pass. If the column is blank, an impactor was not used.

FLIGHT TAPE NO. 8

June 17, 1976

VISIBLE AND DRIFT PLUMES, TEST PLANS 1 AND 2

Pass No.	Altitude (ft)	Pass End Points		Location		Heading		Impactor
		Start	Stop	Section No.	Description	Magnetic Direction (°)	Distance (ft)	
S1	1300-100	1	1	0	Upwind	----	----	--
1	1200	22	4	1	Close	292	495	1
2	1000	4	22	1	Close	112	495	2
3	800	22	4	1	Close	292	495	3
4	500	4	22	1	Close	112	495	4
5	500	22	4	1	Close	292	495	4
6	800	4	22	1	Close	112	495	3
7	1000	22	4	1	Close	292	495	2
8	1200	4	22	1	Close	112	495	1
9	1200	22	4	1	Close	292	495	1
10	1000	4	22	1	Close	112	495	2
11	800	22	4	1	Close	292	495	3
12	500	4	22	1	Close	112	495	4
13	500	22	4	1	Close	292	495	--
14	800	4	22	1	Close	112	495	3
15	1000	22	4	1	Close	292	495	2
16	1200	4	22	1	Close	112	495	1
17	1200	22	4	1	Close	292	495	1
18	1000	4	22	1	Close	112	495	2
19	800	22	4	1	Close	292	495	3
20	500	4	22	1	Close	112	495	4
21	500	22	4	1	Close	292	495	4
22	800	4	22	1	Close	112	495	3
23	1000	22	4	1	Close	292	495	2
24	1200	4	22	1	Close	112	495	1
25	1200	22	4	1	Close	292	495	1
26	1000	4	22	1	Close	112	495	2
27	800	22	4	1	Close	292	495	3
28	500	4	22	1	Close	112	495	4
29	500	22	4	1	Close	292	495	4
30	800	4	22	1	Close	112	495	3
31	1000	22	4	1	Close	292	495	2
32	1200	4	22	1	Close	112	495	1
33	1200	22	4	1	Close	292	495	1
34	1000	4	22	1	Close	112	495	2
35	800	22	4	1	Close	292	495	3
36	500	4	22	1	Close	112	495	4
37	500	22	4	1	Close	292	495	4
38	800	4	22	1	Close	112	495	3
39	100	22	4	1	Close	292	495	2

FLIGHT TAPE NO. 8 (Continued)

June 17, 1976

VISIBLE AND DRIFT PLUMES, TEST PLANS 1 AND 2

Pass No.	Altitude (ft)	Pass End Points		Location		Heading		Impactor
		Start	Stop	Section No.	Description	Magnetic Direction (°)	Distance (ft)	
40	1200	4	22	1	Close	112	495	1
41	1200	22	4	1	Close	292	495	1
42	1000	4	22	1	Close	112	495	2
43	800	22	4	1	Close	292	495	3
44	500	4	22	1	Close	112	495	4
45	500	24	6	2	L/2	278	1344	--
46	850	6	24	2	L/2	98	1344	--
47	1000	24	6	2	L/2	278	1344	--
48	1200	6	24	2	L/2	98	1344	--
49	1400	24	6	2	L/2	278	1344	--
50	1400	6	24	2	L/2	98	1344	--
51	1200	24	6	2	L/2	278	1344	--
52	1000	6	24	2	L/2	98	1344	--
53	800	24	6	2	L/2	278	1344	--
54	500	6	24	2	L/2	98	1344	--
55	300	24	6	2	L/2	278	1344	--
56	300	6	24	2	L/2	98	1344	--
57	500	24	6	2	L/2	278	1344	--
58	800	6	24	2	L/2	98	1344	--
59	1000	24	6	2	L/2	278	1344	--
60	1200	6	24	2	L/2	98	1344	--
61	1200	24	6	2	L/2	278	1344	--
62	1000	6	24	2	L/2	98	1344	--
63	800	24	6	2	L/2	278	1344	--
64	500	6	24	2	L/2	98	1344	--
65	300	24	6	2	L/2	278	1344	--
66	300	6	24	2	L/2	98	1344	--
67	500	24	6	2	L/2	278	1344	--
68	800	6	24	2	L/2	98	1344	--
69	1000	24	6	2	L/2	278	1344	--
70	1200	6	24	2	L/2	98	1344	--
71	2500	27	26	4	L/2	34	7160	--
72	2250	26	27	4	L/2	214	7160	--
73	2000	27	26	4	L/2	34	7160	--
74	1750	26	27	4	L/2	214	7160	--
75	1500	27	26	4	L/2	34	7160	--
76	1500	26	27	4	L/2	214	7160	--
77	1750	27	26	4	L/2	34	7160	--
78	2000	26	27	4	L/2	214	7160	--

FLIGHT TAPE NO. 8 (Continued)

June 17, 1976

VISIBLE AND DRIFT PLUMES, TEST PLANS 1 AND 2

Pass No.	Altitude (ft)	Pass End Points		Location		Heading		Impactor
		Start	Stop	Section No.	Description	Magnetic Direction (°)	Distance (ft)	
79	2250	27	26	4	L/2	34	7160	--
80	2500	26	27	4	L/2	214	7160	--

FLIGHT TAPE NO. 10

June 18, 1976

VISIBLE PLUME, TEST PLAN 1

Pass No.	Altitude (ft)	Pass End Points		Location		Heading		Impactor
		Start	Stop	Section No.	Description	Magnetic Direction (°)	Distance (ft)	
1	1200	6	22	2	L/2	81	662	--
2	1000	22	6	2	L/2	261	662	--
3	800	6	22	2	L/2	81	662	--
4	300	22	6	2	L/2	261	662	1
5	400	6	22	2	L/2	81	662	2
6	300	22	6	2	L/2	261	662	--
7	300	6	22	2	L/2	81	662	--
8	400	22	6	2	L/2	261	662	--
9	500	6	22	2	L/2	81	662	1
10	800	22	6	2	L/2	261	662	--
11	1000	6	22	2	L/2	81	662	--
12	1200	22	6	2	L/2	261	662	--
13	1200	6	22	2	L/2	81	662	--
14	1000	22	6	2	L/2	261	662	--
15	800	6	22	2	L/2	81	662	--
16	500	22	6	2	L/2	261	662	1
17	500	28	29A	1	Close	189	300	1
18	500	29A	28	1	Close	9	300	1
19	400	28	29A	1	Close	189	300	2
20	300	29A	28	1	Close	9	300	--
21	300	28	29A	1	Close	189	300	--
22	400	29A	28	1	Close	9	300	2
23	500	28	29A	1	Close	189	300	1
24	800	29A	28	1	Close	9	300	--
25	1000	28	29A	1	Close	189	300	--
26	1200	29A	28	1	Close	9	300	--

FLIGHT TAPE NO. 11

June 18, 1976

VISIBLE AND DRIFT PLUMES, TEST PLANS 1 AND 2

Pass No.	Altitude (ft)	Pass End Points		Location		Heading		Impactor
		Start	Stop	Section No.	Description	Magnetic Direction (°)	Distance (ft)	
1	800	4	22	1	Close	112	495	1
2	700	22	4	1	Close	292	495	--
3	600	4	22	1	Close	112	495	2
4	500	22	4	1	Close	292	495	--
5	400	4	22	1	Close	112	495	3
6	300	22	4	1	Close	292	495	4
7	300	4	22	1	Close	112	495	4
8	400	22	4	1	Close	292	495	3
9	500	4	22	1	Close	112	495	--
10	600	22	4	1	Close	292	495	2
11	700	4	22	1	Close	112	495	--
12	800	22	4	1	Close	292	495	1
13	800	4	22	1	Close	112	495	1
14	700	22	4	1	Close	292	495	--
15	600	4	22	1	Close	112	495	2
16	500	22	4	1	Close	292	495	--
17	400	4	22	1	Close	112	495	3
18	300	22	4	1	Close	292	495	4
19	300	4	22	1	Close	112	495	4
20	400	22	4	1	Close	292	495	3
21	500	4	22	1	Close	112	495	--
22	600	22	4	1	Close	292	495	2
23	700	4	22	1	Close	112	495	--
24	800	22	4	1	Close	292	495	1
25	800	4	22	1	Close	112	495	1
26	700	22	4	1	Close	292	495	--
27	600	4	22	1	Close	112	495	2
28	500	22	4	1	Close	292	495	--
29	400	4	22	1	Close	112	495	3
30	300	22	4	1	Close	292	495	4
31	800	24	6	2	L/2	278	1344	--
32	600	6	5	2	L/2	96	1280	--
33	400	5	6	2	L/2	276	1280	--
34	300	6	5	2	L/2	96	1280	--
35	300	5	6	2	L/2	276	1280	--
36	400	6	5	2	L/2	96	1280	--
37	600	5	6	2	L/2	276	1280	--
38	800	6	5	2	L/2	96	1280	--
39	800	5	6	2	L/2	276	1280	--

FLIGHT TAPE NO. 11 (Continued)

June 18, 1976

VISIBLE AND DRIFT PLUMES, TEST PLANS 1 AND 2

Pass No.	Altitude (ft)	Pass End Points		Location		Heading		Impactor
		Start	Stop	Section No.	Description	Magnetic Direction (°)	Distance (ft)	
40	600	6	5	2	L/2	96	1280	--
41	400	5	6	2	L/2	276	1280	--
42	300	6	5	2	L/2	96	1280	--
43	300	5	6	2	L/2	276	1280	--
44	400	6	5	2	L/2	96	1280	--
45	600	5	6	2	L/2	276	1280	--
46	800	6	5	2	L/2	96	1280	--
47	800	5	6	2	L/2	276	1280	--
48	600	6	5	2	L/2	96	1280	--
49	400	5	6	2	L/2	276	1280	--
50	300	6	5	2	L/2	96	1280	--
51	800	4	22	1	Close	112	495	--
52	700	22	4	1	Close	292	495	--
53	600	4	22	1	Close	112	495	--
54	500	22	4	1	Close	292	495	--
55	400	4	22	1	Close	112	495	--
56	300	22	4	1	Close	292	495	--
57	300	4	22	1	Close	112	495	--
58	400	22	4	1	Close	292	495	--
59	500	4	22	1	Close	112	495	--

FLIGHT TAPE NO. 12

June 19, 1976

DRIFT PLUME, TEST PLAN 2

Pass No.	Altitude (ft)	Pass End Points		Location		Heading		Impactor
		Start	Stop	Section No.	Description	Magnetic Direction (°)	Distance (ft)	
S1	328-3182	1	1	0	Upwind	---	---	--
1	300	4	22	1	Close	112	495	1
2	300	22	4	1	Close	292	495	1
3	300	4	22	1	Close	112	495	1
4	300	22	4	1	Close	292	495	1
5	300	4	22	1	Close	112	495	1
6	300	22	4	1	Close	292	495	1
7	300	4	22	1	Close	112	495	1
8	300	22	4	1	Close	292	495	1
9	300	4	22	1	Close	112	495	1
10	300	22	4	1	Close	292	495	1
11	300	6	5	2	L/2	96	1280	2
12	300	5	6	2	L/2	276	1280	2
13	300	6	5	2	L/2	96	1280	2
14	300	5	6	2	L/2	276	1280	2
15	300	6	5	2	L/2	96	1280	2
16	300	5	6	2	L/2	276	1280	2
17	300	6	5	2	L/2	96	1280	2
18	300	5	6	2	L/2	276	1280	2
19	300	6	5	2	L/2	96	1280	2
20	350	19	31	4	2L	82	3680	3
21	300	31	19	4	2L	263	3680	3
22	300	19	31	4	2L	82	3680	3
23	300	31	19	4	2L	263	3680	3
24	350	19	31	4	2L	82	3680	3
25	300	31	19	4	2L	263	3680	3
26	350	19	31	4	2L	82	3680	3
27	300	31	19	4	2L	263	3680	3
28	350	19	31	4	2L	82	3680	3
29	300	31	19	4	2L	263	3680	3
30	300	4	22	1	Close	112	495	--
31	300	22	4	1	Close	292	495	--
32	300	4	22	1	Close	112	495	--
33	300	22	4	1	Close	292	495	--
34	300	4	22	1	Close	112	495	--
35	300	22	4	1	Close	292	495	--
36	300	4	22	1	Close	112	495	--
37	300	22	4	1	Close	292	495	--
38	300	4	22	1	Close	112	495	--

FLIGHT TAPE NO. 12 (Continued)

June 19, 1976

DRIFT PLUME, TEST PLAN 2

Pass No.	Altitude (ft)	Pass End Points		Location		Heading		Impactor
		Start	Stop	Section No.	Description	Magnetic Direction (°)	Distance (ft)	
39	300	22	4	1	Close	292	495	--
40	300	6	5	2	L/2	96	1280	--
41	300	5	6	2	L/2	276	1280	--
42	300	6	5	2	L/2	96	1280	--
43	300	5	6	2	L/2	276	1280	--
44	300	6	5	2	L/2	96	1280	--
45	300	5	6	2	L/2	276	1280	--
46	300	6	5	2	L/2	96	1280	--
47	300	5	6	2	L/2	276	1280	--
48	300	6	5	2	L/2	96	1280	--
49	300	5	6	2	L/2	276	1280	--
50	300	19	31	4	2L	82	3680	--
51	300	31	19	4	2L	263	3680	--
52	300	19	31	4	2L	82	3680	--
53	300	31	19	4	2L	263	3680	--
54	300	19	31	4	2L	82	3680	--
55	300	31	19	4	2L	263	3680	--
56	350	19	31	4	2L	82	3680	--
57	300	31	19	4	2L	263	3680	--
58	350	19	31	4	2L	82	3680	--
59	300	31	19	4	2L	263	3680	--
S2	164-3156	1	1	0	Upwind	---	---	--
60	300	4	22	1	Close	112	495	--
61	300	22	4	1	Close	292	495	--
62	300	4	22	1	Close	112	495	--
63	300	22	4	1	Close	292	495	--
64	300	4	22	1	Close	112	495	--
65	300	22	4	1	Close	292	495	--
66	300	4	22	1	Close	112	495	--
67	300	5	6	2	L/2	276	1280	--
68	300	6	5	2	L/2	96	1280	--
69	300	5	6	2	L/2	276	1280	--
70	300	6	5	2	L/2	96	1280	--
71	300	5	6	2	L/2	276	1280	--
72	350	19	31	4	2L	82	3680	--
73	350	31	19	4	2L	263	3680	--
74	350	19	31	4	2L	82	3680	--
75	350	31	19	4	2L	263	3680	
76	350	19	31	4	2L	82	3680	

FLIGHT TAPE NO. 13

June 21, 1976

VISIBLE PLUME, TEST PLAN 1

Pass No.	Altitude (ft)	Pass End Points		Location		Heading		Impactor
		Start	Stop	Section No.	Description	Magnetic Direction (°)	Distance (ft)	
1	800	4	22	1	Close	112	495	--
2	700	22	4	1	Close	292	495	1
3	600	4	22	1	Close	112	495	--
4	500	22	4	1	Close	292	495	2
5	400	4	22	1	Close	112	495	--
6	300	22	4	1	Close	292	495	3
7	350	4	22	1	Close	112	495	3
8	400	22	4	1	Close	292	495	--
9	500	4	22	1	Close	112	495	2
10	700	22	4	1	Close	292	495	1

FLIGHT TAPE NO. 14

June 22, 1976

VISIBLE PLUME, TEST PLAN 1

Pass No.	Altitude (ft)	Pass End Points		Location		Heading		Impactor
		Start	Stop	Section No.	Description	Magnetic Direction (°)	Distance (ft)	
1	1000	22	4	1	Close	292	495	--
2	900	4	22	1	Close	112	495	--
3	800	22	4	1	Close	292	495	--
4	700	4	22	1	Close	112	495	--
5	600	22	4	1	Close	292	495	--
6	500	4	22	1	Close	112	495	--
7	400	22	4	1	Close	292	495	--
8	300	4	22	1	Close	112	495	--
9	300	22	4	1	Close	292	495	4
10	400	4	22	1	Close	112	495	3
11	500	22	4	1	Close	292	495	--
12	600	4	22	1	Close	112	495	--
13	700	22	4	1	Close	292	495	--
14	800	4	22	1	Close	112	495	1
15	900	22	4	1	Close	292	495	--
16	1000	4	22	1	Close	112	495	--
17	1100	22	4	1	Close	292	495	--
18	1200	4	22	1	Close	112	495	--
19	1200	22	4	1	Close	292	495	--
20	1100	4	22	1	Close	112	495	--
21	1000	22	4	1	Close	292	495	--
22	900	4	22	1	Close	112	495	--
23	800	22	4	1	Close	292	495	1
24	700	4	22	1	Close	112	495	--
25	600	22	4	1	Close	292	495	2
26	500	4	22	1	Close	112	495	--
27	400	22	4	1	Close	292	495	3
28	300	4	22	1	Close	112	495	4
29	300	22	4	1	Close	292	495	4
30	400	4	22	1	Close	112	495	3
31	500	22	4	1	Close	292	495	--
32	600	4	22	1	Close	112	495	2
33	700	22	4	1	Close	292	495	--
34	800	4	22	1	Close	112	495	1
35	900	22	4	1	Close	292	495	--
36	1000	4	22	1	Close	112	495	--
37	1100	22	4	1	Close	292	495	--
38	1200	4	22	1	Close	112	495	--
39	1200	22	4	1	Close	292	495	--

FLIGHT TAPE NO. 14 (Continued)

June 22, 1976

VISIBLE PLUME, TEST PLAN 1

Pass No.	Altitude (ft)	Pass End Points		Location		Heading		Impactor
		Start	Stop	Section No.	Description	Magnetic Direction (°)	Distance (ft)	
40	1100	4	22	1	Close	112	495	--
41	1000	22	4	1	Close	292	495	--
42	900	4	22	1	Close	112	495	--
43	800	22	4	1	Close	292	495	1
44	700	4	22	1	Close	112	495	--
45	600	22	4	1	Close	292	495	2
46	500	4	22	1	Close	112	495	--
47	400	22	4	1	Close	292	495	3
48	300	4	22	1	Close	112	495	4
49	300	22	4	1	Close	292	495	4
50	400	4	22	1	Close	112	495	3
51	500	22	4	1	Close	292	495	--
52	600	4	22	1	Close	112	495	2
53	700	22	4	1	Close	292	495	--
54	800	4	22	1	Close	112	495	1
55	900	22	4	1	Close	292	495	--
56	1000	4	22	1	Close	112	495	--
57	1100	22	4	1	Close	292	495	--
58	1200	4	22	1	Close	112	495	--
59	1200	22	4	1	Close	292	495	--
60	1100	4	22	1	Close	112	495	--
61	1000	22	4	1	Close	292	495	--
62	900	4	22	1	Close	112	495	--
63	800	22	4	1	Close	292	495	1
64	700	4	22	1	Close	112	495	--
65	600	22	4	1	Close	292	495	2
66	500	4	22	1	Close	112	495	--
67	400	22	4	1	Close	292	495	3
68	300	4	22	1	Close	112	495	4
69	300	22	4	1	Close	292	495	4
70	300	4	22	1	Close	112	495	--
71	300	22	4	1	Close	292	495	--
72	300	4	22	1	Close	112	495	--
73	300	22	4	1	Close	292	495	--
74	300	4	22	1	Close	112	495	--
75	300	22	4	1	Close	292	495	--
76	300	4	22	1	Close	112	495	--
77	300	22	4	1	Close	292	495	--
78	300	6	31	3	L	116	1955	--

FLIGHT TAPE NO. 14 (Continued)

June 22, 1976

VISIBLE PLUME, TEST PLAN 1

Pass No.	Altitude (ft)	Pass End Points		Location		Heading		Impactor
		Start	Stop	Section No.	Description	Magnetic Direction (°)	Distance (ft)	
79	300	31	6	3	L	296	1955	--
80	300	6	31	3	L	116	1955	--
81	300	31	6	3	L	296	1955	--
82	300	6	31	3	L	116	1955	--
83	300	6	31	3	L	116	1955	--
84	300	31	6	3	L	296	1955	--
85	300	6	31	3	L	116	1955	--
86	300	31	6	3	L	296	1955	--
87	300	6	31	3	L	116	1955	--
88	400	22	4	1	Close	292	495	
89	400	4	22	1	Close	112	495	--
90	400	22	4	1	Close	292	495	--
91	400	4	22	1	Close	112	495	--
92	400	22	4	1	Close	292	495	--
93	300	4	22	1	Close	112	495	--
94	300	22	4	1	Close	292	495	--
95	300	4	22	1	Close	112	495	--
96	300	22	4	1	Close	292	495	--
97	300	4	22	1	Close	112	495	--

FLIGHT TAPE NO. 15

June 23, 1976

VISIBLE PLUME AND INTERACTION ZONE, TEST PLANS 1 AND 3

Pass No.	Altitude (ft)	Pass End Points		Location		Heading		Impactor
		Start	Stop	Section No.	Description	Magnetic Direction (°)	Distance (ft)	
1	1700	28	29	1	Over Top	192	0	--
2	1600	29	28	1	Over Top	12	0	--
3	1500	28	29	1	Over Top	192	0	--
4	1400	29	28	1	Over Top	12	0	--
5	1300	28	29	1	Over Top	192	0	--
6	1200	29	28	1	Over Top	12	0	--
7	1100	28	29	1	Over Top	192	0	--
8	1000	29	28	1	Over Top	12	0	--
9	900	28	29	1	Over Top	192	0	--
10	800	29	28	1	Over Top	12	0	--
11	700	28	29	1	Over Top	192	0	--
12	600	29	28	1	Over Top	12	0	--
13	600	28	29	1	Over Top	192	0	--
14	600	29	28	1	Over Top	12	0	--
15	600	28	29	1	Over Top	192	0	--
16	600	29	28	1	Over Top	12	0	--
17	700	28	29	1	Over Top	192	0	--
18	700	29	28	1	Over Top	12	0	--
19	700	28	29	1	Over Top	192	0	--
20	700	29	28	1	Over Top	12	0	--
21	700	28	29	1	Over Top	192	0	--
22	1000	29	28	1	Over Top	12	0	--
23	1000	28	29	1	Over Top	192	0	--
24	1000	29	28	1	Over Top	12	0	--
25	1000	28	29	1	Over Top	192	0	--
26	1000	29	28	1	Over Top	12	0	--
27	1300	28	29	1	Over Top	192	0	--
28	1300	29	28	1	Over Top	12	0	--
29	1300	29	28	1	Over Top	192	0	--
30	1300	29	28	1	Over Top	12	0	--
31	1300	28	29	1	Over Top	192	0	--
32	1500	29	28	1	Over Top	12	0	--
33	1500	28	29	1	Over Top	192	0	--
34	1500	29	28	1	Over Top	12	0	--
35	1500	28	29	1	Over Top	192	0	--
36	1500	28	29	1	Over Top	12	0	--
37	1500	29	28	1	Over Top	192	0	--
38	1500	28	29	1	Over Top	12	0	--
39	1500	29	28	1	Over Top	192	0	--

FLIGHT TAPE NO. 15 (Continued)

June 23, 1976

VISIBLE PLUME AND INTERACTION ZONE, TEST PLANS 1 AND 3

Pass No.	Altitude (ft)	Pass End Points		Location		Heading		Impactor
		Start	Stop	Section No.	Description	Magnetic Direction (°)	Distance (ft)	
40	1500	28	29	1	Over Top	12	0	--
41	1300	29	28	1	Over Top	192	0	--
42	1300	28	29	1	Over Top	12	0	--
43	1300	29	28	1	Over Top	192	0	--
44	1300	28	29	1	Over Top	12	0	--
45	1300	29	28	1	Over Top	192	0	--
46	1300	28	29	1	Over Top	12	0	--
47	1000	29	28	1	Over Top	192	0	--
48	1000	28	29	1	Over Top	12	0	--
49	1000	29	28	1	Over Top	192	0	--
50	1000	28	29	1	Over Top	12	0	--
51	1000	29	28	1	Over Top	192	0	--
52	800	28	29	1	Over Top	12	0	--
53	800	29	28	1	Over Top	192	0	--
54	800	28	29	1	Over Top	12	0	--
55	800	29	28	1	Over Top	192	0	--
56	800	28	29	1	Over Top	12	0	--
57	800	29	28	1	Over Top	192	0	--
58	700	28	29	1	Over Top	12	0	1
59	700	29	28	1	Over Top	192	0	1
60	700	28	29	1	Over Top	12	0	1
61	700	29	28	1	Over Top	192	0	--
62	700	28	29	1	Over Top	12	0	1
63	600	29	28	1	Over Top	192	0	2
64	600	28	29	1	Over Top	12	0	2
65	600	29	28	1	Over Top	192	0	2
66	600	28	29	1	Over Top	12	0	2
67	600	29	28	1	Over Top	192	0	2
68	1000	19	31	4	2L	82	3680	3
69	1000	31	19	4	2L	263	3680	3
70	1000	19	31	4	2L	82	3680	3
71	1000	24	6	2	L/2	278	1344	4
72	1000	6	24	2	L/2	98	1344	4
73	1000	24	6	2	L/2	278	1344	4
74	1000	6	24	2	L/2	98	1344	4
75	1000	24	6	2	L/2	278	1344	4

FLIGHT TAPE NO. 16

June 24, 1976

VISIBLE AND DRIFT PLUMES, TEST PLANS 1 AND 2

Pass No.	Altitude (ft)	Pass End Points		Location		Heading		Impactor
		Start	Stop	Section No.	Description	Magnetic Direction (°)	Distance (ft)	
1	300	22	4	1	Close	292	495	--
2	400	4	22	1	Close	112	495	4
3	500	22	4	1	Close	292	495	3
4	600	4	22	1	Close	112	495	2
5	700	22	4	1	Close	292	495	1
6	800	4	22	1	Close	112	495	--
7	900	22	4	1	Close	292	495	--
8	1000	4	22	1	Close	112	495	--
9	1100	22	4	1	Close	292	495	--
10	1200	4	22	1	Close	112	495	--
11	1400	22	4	1	Close	292	495	--
12	1200	4	22	1	Close	112	495	--
13	1000	22	4	1	Close	292	495	--
14	900	4	22	1	Close	112	495	--
15	800	22	4	1	Close	292	495	1
16	700	4	22	1	Close	112	495	2
17	600	22	4	1	Close	292	495	2
18	500	4	22	1	Close	112	495	3
19	400	22	4	1	Close	292	495	4
20	300	4	22	1	Close	112	495	--
21	300	22	4	1	Close	292	495	--
22	400	4	22	1	Close	112	495	4
23	500	22	4	1	Close	292	495	3
24	600	4	22	1	Close	112	495	2
25	700	22	4	1	Close	292	495	1
26	800	4	22	1	Close	112	495	--
27	900	22	4	1	Close	292	495	--
28	1000	4	22	1	Close	112	495	--
29	1200	22	4	1	Close	292	495	--
30	1400	4	22	1	Close	112	495	--
31	1400	22	4	1	Close	292	495	--
32	1200	4	22	1	Close	112	495	--
33	1000	22	4	1	Close	292	495	--
34	900	4	22	1	Close	112	495	--
35	800	22	4	1	Close	292	495	--
36	700	4	22	1	Close	112	495	1
37	600	22	4	1	Close	292	495	2
38	500	4	22	1	Close	112	495	3
39	400	22	4	1	Close	292	495	4

FLIGHT TAPE NO. 16 (Continued)

June 24, 1976

VISIBLE AND DRIFT PLUMES, TEST PLANS 1 AND 2

Pass No.	Altitude (ft)	Pass End Points		Location		Heading		Impactor
		Start	Stop	Section No.	Description	Magnetic Direction (°)	Distance (ft)	
40	300	22	4	1	Close	292	495	4
41	300	4	22	1	Close	112	495	--
42	400	22	4	1	Close	292	495	4
43	500	4	22	1	Close	112	495	3
44	600	22	4	1	Close	292	495	2
45	700	4	22	1	Close	112	495	1
46	800	22	4	1	Close	292	495	--
47	900	4	22	1	Close	112	495	--
48	1000	22	4	1	Close	292	495	--
49	1100	4	22	1	Close	112	495	--
50	1200	22	4	1	Close	292	495	--
51	1200	4	22	1	Close	112	495	--
52	1200	6	24	2	L/2	98	1344	--
53	1000	24	6	2	L/2	278	1344	--
54	800	6	24	2	L/2	98	1344	--
55	700	24	6	2	L/2	278	1344	--
56	600	6	24	2	L/2	98	1344	--
57	500	24	6	2	L/2	278	1344	--
58	400	6	24	2	L/2	98	1344	--
59	300	24	6	2	L/2	278	1344	--
60	350	6	24	2	L/2	98	1344	--
61	400	24	6	2	L/2	278	1344	--
62	500	6	24	2	L/2	98	1344	--
63	600	24	6	2	L/2	278	1344	--
64	700	6	24	2	L/2	98	1344	--
65	800	24	6	2	L/2	278	1344	--
66	1000	6	24	2	L/2	98	1344	--
67	1200	24	6	2	L/2	278	1344	--
68	300	22	4	1	Close	112	495	--
69	400	4	22	1	Close	292	495	4
70	500	22	4	1	Close	112	495	3
71	600	4	22	1	Close	292	495	2
72	700	22	4	1	Close	112	495	1
73	800	4	22	1	Close	292	495	--
74	900	22	4	1	Close	112	495	--
75	1000	4	22	1	Close	292	495	--
76	1100	22	4	1	Close	112	495	--
77	1200	24	6	2	L/2	278	1344	--
78	1000	6	24	2	L/2	98	1344	--

FLIGHT TAPE NO. 16 (Continued)

June 24, 1976

VISIBLE AND DRIFT PLUMES, TEST PLAN 1 AND 2

Pass No.	Altitude (ft)	Pass End Points		Location		Heading		Impactor
		Start	Stop	Section No.	Description	Magnetic Direction (°)	Distance (ft)	
79	800	24	6	2	L/2	278	1344	--
80	600	6	24	2	L/2	98	1344	--
81	400	24	6	2	L/2	278	1344	--
82	300	6	24	2	L/2	98	1344	--

FLIGHT TAPE NO. 17

June 25, 1976

LONG RANGE BOILER PLUME

Pass No.	Altitude (ft)	Pass End Points		Location		Heading		Impactor
		Start	Stop	Section No.	Description	Magnetic Direction (°)	Distance (ft)	
S1	663-10285	1	1	0	Upwind	---	---	--
S2	10285-102	1	1	0	Upwind	---	---	--
1	700	6	1	2	L/2	169	3520	2
2	300	1	6	2	L/2	349	3520	2
3	600	6	1	2	L/2	169	3520	2
4	900	1	6	2	L/2	349	3520	2
5	1200	6	1	2	L/2	169	3520	2
6	1500	1	6	2	L/2	349	3520	2
7	1500	101	102	4	2L+	357	10 mi.*	2
8	1000	102	101	4	2L+	177	10 mi.*	2
99	500	101	102	4	2L+	357	10 mi.*	2
10	200	102	101	4	2L+	177	10 mi.*	2
11	300	104	103	4	2L+	188	9.5 mi.*	2
12	600	103	104	4	2L+	8	9.5 mi.*	2
13	600	104	102	4	2L+	188	9.5 mi.*	2
14	1200	103	104	4	2L+	8	9.5 mi.*	2

* - Approximate miles to flight path downwind (not exactly perpendicular).

End Points:

1 - Teague Point
2 - Mouth of Canal
101 - U.S. Naval Research Laboratory
102 - Breezy Point
103 - Plum Point
104 - Dares Beach

Appendix C

SODIUM CHLORIDE MEASUREMENTS

Appendix C

SODIUM CHLORIDE MEASUREMENTS

Drift droplets containing sodium chloride were measured with the MRI Chemical Film Sampler. Droplets were impacted on a gelatin-coated film, and the salt remained in the coating. The film was treated chemically to produce permanent images of each droplet. The size and number of images were measured with a Quantimet image analyzer to produce size distributions and droplet mass concentrations. The mass calculations assume a droplet spread factor of 2 on the gelatin film, and a specific gravity of 1. The specific gravity will actually be slightly higher because of the salt content, the mass calculations, therefore, tend to be low.

Collection efficiency for the Chemical Film Sampler drops rapidly for droplets below 20 microns diameter. The images left by these small droplets also have diffuse edges and are, therefore, not always counted by the image analyzer. Data in the first size increment may, therefore, be less significant than the others.

Data are identified by a traverse number, e.g., 15:23. The part before the colon identifies the MRI test number; the part following the colon is the individual traverse number or numbers during that test when the sampler was collecting a sample. Each line in the data table, therefore, represents a separate sample of one or more traverses.

The total sample mass is listed under "MASS(GRAMS)". In order to determine the mass concentration in the plume, the mass must be divided by the sample volume. The sample volume is determined from the effective sampling cross section, and the plume width. The effective sampling cross section is the size of film area analyzed by the image analyzer. An area of 4 cm^2 was used to obtain the tabulated results reported here.

"MASS DIAMETERS" refers to the diameter below which 50 percent, 16 percent, and 84 percent of the total sample mass lies. The 50 percent point is the mass median diameter, i.e., 50 percent of the mass is in droplets smaller than this diameter and 50 percent is in larger droplets.

For calculations of salt drift, the mass median is more meaningful than the number counts. In order to determine salt concentration in the plume, salt concentration in the droplets must be assumed. This concentration will normally be in the range between the original cooling tower circulating water concentration and the evaporation equilibrium for droplets containing salt. The 16 percent and 84 percent mass diameters are provided to indicate the degree of skewness of the mass distribution.

The number of droplets counted for each sample traverse is listed under "NUMBER OF DROPLETS PER 14 MICRON DIAMETER SIZE INCREMENT." The numbers directly under the heading are size increment numbers of size "bins." Each size bin is 14 microns wide so that bin 1 contains all droplets from 0 to 14 microns diameter, bin 2 contains droplets from 14 to 28 microns diameter, etc.; and bin 32 contains all droplets larger than 448 microns diameter. These diameters were chosen after determining that there were very few droplets that exceeded 448 microns diameter. All droplet diameters have been corrected by multiplying the image diameters by a spread factor of 2.

CHALK POINT SALT DRIFT DROPLET SIZE DISTRIBUTIONS - JUNE, 1976

TRAVERSE NUMBER	MASS (GRAMS)	MASS DIAMETERS MEDIAN	16%	84%	NUMBER OF DROPLETS PER 14 MICRON DIAMETER SIZE INCREMENT 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
8: 1	.704E-04	441	147	441	6	3	3	5	1	4	3	3	4	0	2	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
8: 2-3	.308E-03	357	189	441	28	10	9	9	12	11	5	6	4	5	12	2	0	2	2	1	2	0	2	2	0	1	0	0	1	1	0	0	0	0	1	2
8: 4	.393E-05	133	105	147	7	3	2	0	1	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8: 5	.137E-04	245	147	245	15	1	2	0	1	2	0	1	1	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8: 6-8	.603E-03	427	315	441	43	7	4	5	4	5	2	4	0	7	0	3	1	2	0	2	0	0	0	0	2	0	2	1	2	0	1	0	1	2	1	6
8: 9-44*	.109E-03	441	329	441	7	8	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	2
8:45	.276E-04	245	203	245	2	1	3	1	2	2	4	0	0	0	0	0	0	0	1	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8:46	.248E-04	259	133	273	8	2	2	3	2	2	4	0	0	2	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
8:47	.529E-04	231	147	273	7	4	2	2	4	2	6	1	3	1	1	1	0	1	1	1	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
8:48	.786E-04	441	189	441	1	2	4	3	0	3	4	0	2	2	0	1	1	1	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
8:49	.379E-03	273	189	413	13	9	18	13	13	12	14	10	11	4	8	2	2	5	4	3	2	4	1	3	3	0	0	1	0	1	1	0	0	1	0	1
8:50-55	.132E-02	441	315	441	51	14	10	12	12	15	9	11	8	9	6	5	3	5	4	3	1	2	0	1	3	1	2	2	1	0	1	0	1	1	2	19
8:56-70*	.483E-03	441	287	441	124	16	6	2	3	2	5	2	1	3	2	0	3	0	1	2	0	3	0	1	2	0	0	0	1	1	0	1	0	0	0	7
8: **	.666E-04	245	175	329	17	4	4	2	5	3	2	4	2	0	2	0	1	1	1	1	0	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0
8:71	.184E-03	329	175	441	33	2	3	3	4	5	6	3	2	5	6	2	4	0	1	0	2	1	0	1	0	0	0	1	0	0	0	0	0	0	0	2
8:72	.957E-04	301	175	441	75	6	4	3	5	6	3	1	1	2	2	0	3	0	1	0	2	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
8:73	.932E-04	287	175	441	23	1	4	3	4	4	5	4	1	0	2	2	2	1	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	1
8:74	.193E-04	175	161	203	13	3	1	1	2	0	1	0	0	1	0	3	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8:75	.130E-03	441	259	441	29	2	2	1	0	2	2	3	1	0	0	1	0	0	1	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	2
8:76-77	.263E-03	441	189	441	79	13	5	6	9	8	11	3	4	5	4	3	1	3	1	1	2	2	0	1	0	0	0	0	0	0	0	0	1	0	0	3
10: 1	.197E-04	301	147	301	24	6	1	5	1	0	1	0	0	1	2	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
10: 2	.896E-04	189	119	245	18	16	9	8	13	10	10	7	6	2	4	3	0	4	0	1	1	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0
10: 3	.329E-03	441	161	441	15	22	33	21	27	3	5	11	5	9	6	6	5	4	3	2	1	0	0	0	0	0	1	0	1	0	0	0	0	0	0	4
10: 4	.147E-05	133	77	133	1	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10: 5	.447E-06	63	49	63	1	0	0	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10: 6	.439E-05	189	91	189	6	1	1	1	1	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10: 7	.175E-05	91	63	105	6	2	5	2	2	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10: 8	.221E-03	441	175	441	25	19	32	29	15	21	16	7	4	4	4	0	4	1	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	3
10: 9	.360E-03	315	161	441	63	23	28	26	18	16	16	5	9	11	6	4	4	1	3	1	1	2	0	1	1	3	1	0	0	0	0	1	0	0	0	3
10:10	.154E-03	315	147	441	16	13	26	21	18	13	7	7	4	5	3	4	1	0	0	2	2	1	0	0	0	0	1	0	1	0	0	0	0	0	0	1
10:11	.223E-03	259	175	441	76	24	22	18	16	11	6	7	5	7	2	0	5	2	4	3	2	1	2	1	0	1	0	0	0	0	0	1	0	0	0	1
10:12	.265E-03	217	119	441	44	40	57	44	49	41	29	17	12	12	8	7	5	4	1	2	2	0	1	0	0	1	0	0	1	1	0	0	0	0	0	1
11: 2	.190E-03	259	161	441	37	19	10	10	10	11	8	6	5	7	3	2	5	1	1	3	1	2	1	0	0	0	0	1	0	1	0	0	0	0	0	1
11: 3	.332E-04	203	161	259	9	2	1	1	2	0	2	0	0	1	1	1	0	2	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
11: 4	.536E-04	203	133	329	1	0	3	2	5	4	4	5	2	2	2	1	2	1	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
11: 5	.787E-05	231	105	231	36	3	0	0	0	0	2	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11: 6	.662E-05	203	147	203	4	0	0	3	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11: 7-12	.449E-03	357	203	413	19	4	10	7	7	8	5	10	6	7	7	6	4	1	2	3	1	1	1	0	2	2	1	2	0	1	1	1	2	1	0	1
11:13-18	.429E-03	371	189	441	18	3	8	9	7	10	8	7	7	8	3	8	5	3	5	3	2	1	1	1	2	1	1	0	0	0	1	2	0	0	0	3
11:19-30	.735E-03	427	259	441	12	1	7	8	5	0	4	10	7	4	2	5	3	4	3	0	2	1	3	1	0	1	2	1	1	1	0	1	2	0	1	8
11:31	.382E-03	371	189	441	6	0	5	5	10	10	6	6	12	5	3	2	3	5	6	1	1	0	0	1	2	0	1	0	0	1	2	1	1	0	0	2
11:32	.791E-05	217	147	217	2	0	1	0	0	0	0	0	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11:33	.872E-06	105	63	105	0	1	0	0	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11:34	.219E-05	161	161	161	5	2	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11:35	.149E-04	189	189	231	0	0	1	1	1	1	0	0	1	0	0	0	0	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11:36-42	.164E-03	301	189	399	4	1	4	3	4	1	3	5	2	0	2	3	3	4	2	2	0	0	0	0	1	1	0	1	0	0	1	0	1	0	0	0
11:43-51	.816E-03	427	287	441	15	7	5	8	8	7	7	5	3	6	2	3	3	4	3	4	2	1	0	2	1	1	2	1	1	2	1	0	1	1	1	9
11:52-60	.468E-03	441	217	441	8	3	1	5	6	6	4	7	4	2	3	2	3	8	3	3	1	1	1	1	0	2	1	0	0	0	0	1	0	0	0	6
12: 1	.170E-04	175	133	231	17	2	0	0	1	1	2	0	1	1	1	0	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12: 1-5	.486E-04	441	441	441	0	0	1	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
12: 6-10	.952E-04	441	441	441	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
12:11-15	.157E-04	189	189	231	0	0	0	0	0	0	0	0	0	0	0	1	0	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

* Questionable data, large samples gave droplet overlap

**In plume but not of traverse sampling

CHALK POINT SALT DRIFT DROPLET SIZE DISTRIBUTIONS - JUNE, 1976

TRAVERSE NUMBER	MASS (GRAMS)	MASS DIAMETERS MEDIAN	16%	84%	NUMBER OF DROPLETS PER 14 MICRON DIAMETER SIZE INCREMENT 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
12:16-19	.268E-04	371	371	371	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
12:20-24	.666E-05	217	119	217	28	16	4	2	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12:25-29	.589E-04	385	217	385	42	17	2	3	0	2	1	2	0	2	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0
12:30-34	.454E-04	441	441	441	16	6	2	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
12:35-39	.198E-04	301	217	301	6	5	3	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
12:40-44	.239E-04	245	175	259	28	10	3	4	0	1	0	0	1	0	0	0	2	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
12:45-49	.663E-04	399	273	399	28	6	4	1	1	1	1	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	1	0	0	0
12:50-54	.121E-04	259	147	259	18	8	1	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
12:55-59	.753E-05	231	231	231	16	6	2	0	0	0	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12:60	.292E-04	315	175	315	3	5	1	1	1	1	1	1	1	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0
12:61-66	.103E-04	245	161	245	15	7	3	1	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12:67-71	.441E-05	203	203	203	15	6	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12:72-76	.186E-04	203	119	217	66	22	8	2	4	1	1	2	3	1	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13: 1	.369E-05	119	119	147	1	1	0	2	1	0	0	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13: 2	.208E-03	357	259	441	10	3	1	2	0	1	1	1	2	0	2	1	0	0	1	0	1	1	1	1	1	1	0	0	1	1	0	0	0	0	0	2
13: 3	.178E-03	343	203	441	37	10	6	5	5	3	1	1	0	1	0	0	3	3	3	1	1	0	1	0	0	1	1	0	1	1	0	0	0	0	0	1
13: 4	.348E-04	217	175	301	21	6	1	1	0	0	1	0	2	0	0	1	1	1	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
13: 5	.753E-04	441	231	441	5	3	3	0	0	1	0	1	1	0	1	1	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1
13: 6	.956E-04	315	231	357	15	3	3	2	1	2	0	1	0	0	1	0	1	0	1	0	1	1	0	0	1	0	1	1	0	1	0	0	0	0	0	0
13: 7	.118E-03	371	259	413	77	22	8	5	1	2	0	1	0	0	0	0	1	0	1	1	0	0	1	0	0	1	1	0	0	0	1	0	0	1	0	0
13: 8	.804E-06	105	49	105	59	4	2	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13: 9	.770E-05	245	245	245	12	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14: 0	.235E-03	273	147	343	14	14	12	18	13	12	10	10	9	3	6	3	3	2	4	3	1	2	0	3	1	1	0	1	2	0	0	0	0	0	0	0
14: 1	.716E-07	49	49	49	2	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14: 1	.143E-04	301	301	301	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
14: 2	.126E-04	259	189	259	3	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
14: 4	.128E-04	273	147	273	21	2	3	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
14: 5	.326E-06	77	49	77	35	4	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14: 6	.110E-03	273	217	441	14	0	0	0	0	1	1	0	2	1	2	0	2	0	0	2	2	0	2	1	0	0	0	0	0	0	0	0	0	0	0	1
14: 7	.772E-04	441	357	441	25	4	0	2	0	1	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
14: 8	.462E-05	203	203	203	2	1	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14: 9-11	.842E-05	203	175	203	6	1	0	0	0	0	0	0	0	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14:12-18	.103E-03	441	441	441	33	2	2	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2
14:19-26*	.912E-03	441	315	441	17	7	7	1	6	3	7	6	5	4	5	3	6	5	4	2	4	0	0	1	1	0	3	1	1	2	1	1	0	1	0	12
14:27-31	.238E-03	329	203	441	21	3	3	5	2	2	3	1	3	4	4	0	3	2	2	3	1	1	1	1	1	1	0	1	0	0	1	1	0	0	0	1
14:32-39	.539E-03	441	231	441	29	3	2	6	5	3	3	2	2	3	3	7	3	2	6	2	2	1	1	1	3	0	1	1	0	0	0	1	0	0	0	7
14:40-45*	.974E-03	441	301	441	14	4	5	4	6	10	3	7	5	6	1	1	3	2	5	0	3	0	1	2	0	4	0	1	1	2	0	0	0	0	0	16
14:46-51	.534E-04	259	161	357	2	0	2	2	1	0	1	2	1	0	1	2	1	1	0	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0
14:52-58*	.105E-02	441	315	441	7	3	4	6	3	8	7	5	5	4	5	5	3	3	2	5	2	2	0	2	1	0	2	1	0	2	1	0	2	1	1	14
14:59-65*	.103E-02	441	301	441	13	2	2	2	3	4	4	3	3	5	2	2	6	4	2	3	3	2	2	0	2	1	1	2	1	2	1	2	1	1	0	13
14:66-69	.388E-04	399	399	399	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
14:70-77	.636E-04	441	175	441	26	2	1	0	0	2	1	0	0	1	1	2	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
14:78-87	.898E-04	441	441	441	14	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
14:88-92	.623E-07	49	49	49	4	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14:93-96	.308E-04	329	189	329	6	0	1	0	0	0	0	2	1	0	0	1	0	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
15: 0	.270E-04	273	273	287	3	4	2	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0
15: 1	.214E-03	259	189	441	15	0	0	0	1	1	1	3	4	2	5	4	3	2	2	4	2	2	1	2	1	0	0	0	0	0	1	0	0	0	0	1
15: 2	.347E-04	175	161	245	4	2	2	1	1	0	1	0	0	1	1	2	4	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15: 3	.299E-03	329	231	385	9	0	4	2	2	3	4	4	4	5	3	0	1	1	0	3	2	2	2	3	1	0	1	1	1	1	1	2	0	0	0	0
15: 4	.519E-04	371	175	371	8	3	0	0	0	2	4	0	0	0	0	1	2	1	0	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
15: 5	.259E-03	315	189	441	4	5	2	1	3	5	3	4	7	5	2	4	2	4	1	2	1	0	0	1	0	1	3	0	0	1	0	0	0	0	0	2
15: 6	.235E-03	329	217	441	11	3	2	1	1	0	3	3	2	2	2	0	1	2	1	3	0	0	2	0	2	0	1	1	0	0	0	1	0	0	1	1

* Questionable data, large samples gave droplet overlap

CHALK POINT SALT DRIFT DROPLET SIZE DISTRIBUTIONS - JUNE, 1976

TRAVERSE NUMBER	MASS (GRAMS)	MASS DIAMETERS MEDIAN	16%	84%	NUMBER OF DROPLETS PER 14 MICRON DIAMETER SIZE INCREMENT 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
15: 7	.260E-03	343	245	413	5	3	3	3	1	2	1	1	2	2	3	1	0	0	1	2	2	3	2	0	1	1	0	1	1	0	0	0	1	1	1	0
15: 8	.146E-03	287	175	441	9	3	1	3	2	3	5	6	1	1	3	2	2	1	2	0	2	3	0	0	1	0	1	0	0	0	0	0	0	0	0	1
15: 9	.278E-03	399	231	441	38	5	1	2	2	1	0	1	0	4	2	3	1	1	2	1	2	2	0	1	1	0	0	0	0	0	1	0	1	0	1	2
15:10	.129E-03	259	189	371	14	3	4	3	1	3	2	2	2	3	2	0	2	1	0	3	1	2	2	1	0	1	0	0	0	0	1	0	0	0	0	0
15:11	.827E-04	231	161	259	20	1	0	1	3	2	1	3	3	3	2	1	2	1	1	2	2	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0
15:12	.386E-03	343	203	441	35	8	9	5	10	8	6	5	10	3	2	3	2	2	4	0	3	1	1	0	1	0	1	2	2	0	0	0	0	0	0	4
15:13	.237E-03	273	203	441	39	0	0	0	5	4	2	5	3	1	1	1	3	0	4	0	2	4	1	3	0	1	1	2	0	0	0	0	0	0	0	1
15:14	.146E-03	273	161	441	40	4	4	6	9	6	7	4	4	2	3	3	2	3	3	2	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1
15:15	.330E-03	315	203	441	39	5	3	6	1	5	5	4	3	4	5	5	4	1	3	3	4	4	0	2	0	0	1	1	0	1	1	0	0	0	0	2
15:16	.739E-04	329	175	371	16	4	2	1	2	1	2	1	0	2	3	1	2	1	0	0	0	1	0	0	0	0	0	1	0	0	1	0	0	0	0	0
15:17	.337E-03	343	217	441	2	10	4	6	2	5	7	4	4	2	4	4	3	0	3	1	2	0	1	1	1	1	2	1	1	0	1	0	1	0	0	2
15:18	.135E-03	371	175	441	12	0	1	2	3	0	3	4	4	3	2	2	3	2	1	1	1	0	0	0	1	0	0	0	0	0	1	0	0	0	0	1
15:19	.147E-03	301	189	427	15	2	1	2	1	0	3	4	3	2	1	2	2	4	0	3	1	1	0	0	0	1	0	0	0	0	1	0	0	0	1	0
15:20	.299E-03	399	203	441	13	2	9	10	11	8	5	6	6	5	2	5	3	1	1	3	0	2	1	0	1	0	0	0	0	0	1	0	1	0	0	3
15:21	.142E-03	385	189	441	10	2	4	2	3	6	1	2	3	2	3	0	1	2	1	0	1	1	0	1	0	1	0	0	0	0	0	1	0	0	0	1
15:22	.198E-03	399	245	441	39	5	5	5	5	3	2	5	0	1	2	0	2	1	0	2	0	1	0	2	0	0	1	0	0	0	0	0	1	0	0	2
15:23	.166E-03	301	231	441	33	5	1	2	1	2	2	1	0	2	1	2	0	0	2	1	1	0	2	1	0	3	0	1	0	0	0	0	0	0	0	1
15:24	.428E-03	441	357	441	51	4	3	3	1	2	1	1	2	0	2	1	0	1	2	0	1	0	1	1	0	0	1	0	0	1	0	1	0	0	1	6
15:26	.222E-03	301	175	441	5	5	3	8	4	2	5	6	2	5	6	2	3	0	2	0	2	0	1	1	1	2	1	0	0	0	0	0	0	0	1	1
15:27	.446E-03	329	189	441	15	9	13	8	7	13	9	10	6	5	8	6	4	4	3	0	3	1	3	1	1	1	2	1	0	1	2	0	0	0	0	3
15:28	.231E-03	413	203	441	13	2	3	5	7	8	8	5	2	0	2	0	4	2	1	3	2	1	2	0	1	0	0	0	0	0	0	0	0	1	0	2
15:29	.219E-03	343	203	441	12	6	6	6	7	9	5	1	3	4	2	1	1	3	1	2	0	1	2	0	0	0	1	1	1	0	0	0	0	0	0	2
15:30	.202E-03	441	217	441	12	10	4	3	1	4	5	4	3	1	3	0	1	2	1	1	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	3
15:32	.200E-03	315	147	441	20	8	10	7	5	5	7	2	4	9	7	2	3	2	2	1	1	0	0	1	0	1	1	0	0	0	0	0	0	0	1	1
15:33	.531E-04	245	119	287	6	2	2	8	7	3	2	3	5	1	1	1	1	0	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0
15:34	.199E-03	287	161	441	11	12	14	6	5	7	6	8	4	7	3	3	2	3	0	2	1	1	1	0	2	0	0	0	0	0	0	0	0	0	0	2
15:35	.570E-04	231	175	273	2	2	3	3	3	1	1	3	1	1	1	1	2	1	2	0	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
15:36	.246E-03	413	189	441	11	13	11	6	6	6	2	3	1	2	2	3	4	3	3	0	1	3	1	1	0	0	1	0	0	0	0	0	0	1	0	2
15:37	.219E-03	245	161	413	18	15	18	13	10	10	5	4	8	6	5	7	2	3	1	1	2	5	2	0	1	0	0	0	0	0	1	0	0	1	0	0
15:38	.943E-04	273	147	371	3	8	8	4	3	2	4	1	4	4	5	1	0	0	0	1	0	1	1	1	1	0	0	0	0	0	1	0	0	0	0	0
15:39	.213E-03	385	231	441	13	11	10	13	7	2	5	5	1	4	0	3	1	0	1	1	1	1	2	0	1	0	1	0	0	0	0	1	0	0	0	2
15:40	.857E-04	273	147	399	5	7	2	7	2	2	7	3	2	4	2	1	3	1	0	1	1	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0
15:41	.134E-03	287	217	427	5	5	4	6	4	5	2	3	1	0	1	1	1	1	1	1	2	1	0	1	1	0	0	0	0	1	0	0	0	0	1	0
15:42	.156E-04	175	119	231	7	2	1	4	2	1	1	2	2	0	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15:43	.136E-03	203	133	301	35	6	10	11	10	13	6	2	7	7	6	5	4	1	4	1	0	1	0	1	0	1	0	0	1	0	0	0	0	0	0	0
15:45	.126E-03	217	147	259	8	7	8	8	9	5	4	4	5	5	4	1	4	1	2	3	1	1	3	0	0	0	0	1	0	0	0	0	0	0	0	0
15:46	.137E-03	357	161	441	15	6	6	10	9	12	10	4	4	2	2	3	1	0	0	1	2	1	0	0	1	0	0	0	0	1	0	0	0	0	0	1
15:47	.422E-04	203	105	245	12	11	6	11	8	7	6	5	2	2	3	1	0	0	2	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15:48	.174E-03	273	147	441	13	12	8	9	10	11	8	7	4	9	6	5	2	3	1	1	1	0	0	1	0	1	0	0	0	1	0	0	0	0	0	1
15:49	.331E-04	203	133	245	11	3	4	5	3	1	3	2	1	2	3	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15:49	.152E-03	245	133	427	12	13	11	13	8	4	5	9	9	8	3	1	2	2	2	1	0	2	0	0	0	0	0	0	0	0	0	0	1	0	1	0
15:51	.127E-03	245	133	413	14	19	20	13	16	14	11	4	4	4	3	4	1	0	3	0	1	2	0	0	0	0	1	0	0	0	0	0	0	1	0	0
15:52	.190E-03	329	161	441	11	13	11	16	14	9	6	6	7	6	2	2	2	4	1	0	0	0	0	1	0	1	0	2	0	0	1	0	0	0	0	1
15:53	.271E-04	371	371	371	1	4	1	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
15:53	.310E-03	287	161	371	17	10	15	19	16	13	10	8	7	6	9	8	2	1	4	3	3	0	1	0	3	0	2	0	0	2	1	0	1	0	0	0
15:54	.958E-04	203	119	259	16	19	14	22	16	10	9	6	5	5	4	1	3	1	2	3	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
15:55	.183E-03	357	147	441	23	15	18	11	8	18	13	3	7	5	4	4	2	1	1	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	2
15:56	.592E-04	175	105	273	32	3	7	4	8	6	9	7	5	4	0	2	2	0	1	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
15:57	.826E-04	231	147	315	26	5	8	8	12	10	5	3	2	2	1	3	0	1	0	2	2	0	2	0	0	0	1	0	0	0	0	0	0	0	0	0
15:58	.711E-04	175	105	231	29	14	8	16	8	11	10	7	3	5	4	3	1	3	1	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15:59	.124E-03	203	133	287	31	12	14	15	9	11	12	7	5	7	3	2	3	3	4	0	1	2	0	0	1	0	1	0	0	0	0	0	0	0	0	0
15:60	.342E-03	287	161	371	39	12	15	17	19	14	10	13	8	3	6	7	3	4	4	0	2	2	3	0	2	1	1	2	0	0	2	0	0	0	0	1

CHALK POINT SALT DRIFT DROPLET SIZE DISTRIBUTIONS - JUNE, 1976

TRAVERSE NUMBER	MASS (GRAMS)	MASS DIAMETERS			NUMBER OF DROPLETS PER 14 MICRON DIAMETER SIZE INCREMENT																															
		MEDIAN	16%	84%	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
15:61	.677E-04	217	119	343	21	15	10	13	9	10	5	4	4	2	3	2	2	1	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0
15:62	.152E-03	287	147	413	33	14	17	15	11	12	8	7	9	1	4	3	2	2	1	2	0	0	1	0	1	1	1	0	0	0	0	0	0	1	0	0
15:63	.144E-04	245	105	245	13	3	2	3	1	1	3	2	1	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15:64	.289E-03	329	161	441	51	13	23	22	23	17	13	12	5	9	5	5	3	1	2	2	1	1	0	0	1	0	1	1	0	1	1	0	0	0	0	2
15:66	.109E-03	245	147	329	29	15	8	11	5	9	4	4	7	2	2	2	2	2	1	2	0	1	2	0	1	0	0	1	0	0	0	0	0	0	0	0
15:67	.427E-03	357	175	413	79	17	10	21	23	25	23	11	11	6	6	6	2	6	2	3	1	1	2	0	2	1	0	1	0	1	3	0	1	1	0	1
15:68	.629E-03	371	217	441	70	14	27	35	26	19	22	9	12	9	7	4	3	2	2	4	1	3	2	0	2	1	2	0	1	1	2	0	1	0	1	5
15:69	.144E-04	273	105	273	9	2	2	1	1	2	4	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
15:70	.188E-05	147	147	147	2	0	1	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15:71	.619E-07	49	49	49	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15:72	.766E-04	329	119	371	22	10	9	14	16	9	7	6	2	3	2	2	1	1	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0
15:73	.263E-04	147	105	217	16	7	2	12	6	4	2	6	3	2	1	2	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15:74	.103E-03	315	161	441	22	12	13	14	12	5	2	2	1	2	1	3	2	0	0	0	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	1
15:75	.383E-04	357	133	357	2	6	5	4	1	4	2	1	3	1	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
15:76	.505E-04	175	105	217	17	8	17	13	14	8	7	6	2	1	3	2	3	0	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16: 1	.747E-05	133	77	175	23	1	4	4	4	4	1	2	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16: 2	.817E-05	119	91	161	18	2	5	3	2	2	3	2	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16: 3	.265E-05	91	63	105	5	3	3	1	3	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16: 4	.375E-03	301	147	427	87	23	34	42	33	23	10	14	18	10	5	3	3	4	3	1	4	0	4	0	1	1	1	0	1	1	0	1	0	0	1	1
16: 5	.149E-03	217	119	315	41	21	23	20	25	17	15	9	4	4	6	3	2	2	1	3	2	1	0	0	1	0	1	0	1	0	0	0	0	0	0	0
16: 6	.233E-03	273	133	441	86	25	28	32	22	16	25	11	7	8	5	7	3	4	1	2	0	1	0	1	1	0	0	0	1	0	0	0	1	0	0	1
16: 7	.730E-04	441	147	441	19	7	9	18	11	8	3	3	3	1	1	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
16: 8	.301E-04	231	105	287	27	11	8	7	7	5	3	3	3	1	1	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
16: 9	.127E-04	161	77	203	17	9	12	10	6	6	3	3	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16:10	.197E-03	217	119	441	77	34	47	39	24	18	17	12	11	5	7	4	6	2	2	1	0	1	2	0	0	0	0	0	0	0	1	0	0	0	0	1
16:11	.626E-06	77	63	77	15	3	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16:12	.564E-05	147	91	175	29	5	8	5	2	0	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16:13	.760E-04	175	105	245	54	15	16	22	12	13	10	7	3	5	7	1	1	2	1	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0
16:14	.153E-03	413	189	441	61	11	9	9	9	6	7	5	2	1	1	2	1	2	0	0	0	0	1	1	0	0	0	0	0	1	0	0	0	1	0	1
16:15	.133E-03	245	119	441	31	25	32	28	25	13	7	11	5	3	7	2	0	2	1	1	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1
16:16	.743E-04	189	119	245	45	14	8	11	10	5	12	3	4	3	1	5	2	2	1	2	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
16:17	.148E-03	217	119	371	40	24	22	19	18	15	13	13	10	3	1	2	1	2	1	4	1	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0
16:18	.194E-03	287	133	413	45	24	37	25	19	19	14	12	4	7	2	6	2	3	2	0	1	0	1	0	4	0	1	0	0	0	0	0	0	1	0	0
16:19	.501E-07	35	35	35	2	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16:20	.487E-06	63	35	77	2	1	5	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16:21	.162E-04	273	119	273	8	2	0	4	3	1	0	0	2	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
16:22	.246E-04	301	105	301	29	16	9	6	4	2	4	2	0	3	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
16:23	.199E-04	133	77	189	20	13	10	11	9	13	6	3	0	2	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16:24	.131E-03	273	119	385	16	19	23	35	18	13	16	7	5	3	2	2	3	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16:25	.469E-04	161	91	217	19	15	24	21	12	12	3	5	4	1	2	3	1	2	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16:26	.181E-03	203	119	441	46	50	50	43	38	23	19	10	9	5	7	5	3	3	2	0	3	1	0	0	0	0	1	0	0	0	0	0	0	0	0	1
16:27	.519E-04	147	91	287	20	21	23	25	22	13	9	9	3	3	4	1	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
16:28	.203E-03	273	119	399	62	55	59	46	41	25	14	9	9	5	5	5	0	2	5	0	0	0	0	2	1	2	0	1	0	0	0	0	1	0	0	0
16:29	.318E-04	133	77	161	33	30	22	15	21	8	5	5	2	3	3	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16:30	.555E-04	217	91	357	16	16	20	20	10	9	11	4	2	0	1	1	0	0	2	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
16:31	.857E-04	203	91	357	22	31	36	33	19	21	15	6	5	5	3	0	0	1	1	0	0	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0
16:33	.563E-04	133	77	175	32	38	45	36	38	14	15	8	6	5	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16:34	.258E-03	259	133	441	26	56	52	51	48	27	16	14	9	6	5	5	4	3	2	0	1	2	3	1	1	1	0	0	0	0	0	1	0	0	0	1
16:35	.737E-05	231	231	231	8	2	1	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16:36	.251E-03	245	105	399	39	66	72	66	34	32	23	23	13	7	8	4	5	2	3	1	0	1	1	1	0	1	1	0	0	0	0	0	1	1	0	0
16:37	.138E-04	105	63	133	22	21	20	14	10	6	3	4	3	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16:38	.556E-04	133	77	259	25	30	31	30	20	15	11	5	7	5	3	1	1	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0

CHALK POINT SALT DRIFT DROPLET SIZE DISTRIBUTIONS - JUNE, 1976

TRAVERSE	MASS	MASS DIAMETERS			NUMBER OF DROPLETS PER 14 MICRON DIAMETER SIZE INCREMENT																															
NUMBER	(GRAMS)	MEDIAN	16%	84%	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
16:39	.356E-06	77	49	77	6	2	2	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16:40	.214E-05	147	91	147	7	5	0	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16:41	.633E-05	147	91	161	13	5	5	1	1	2	2	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16:42	.602E-05	133	77	161	15	6	2	3	2	2	1	2	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16:43	.333E-04	147	91	231	19	22	21	17	9	10	7	4	2	3	1	1	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16:44	.118E-03	189	105	399	38	56	66	34	28	12	14	10	4	3	5	2	2	5	1	0	1	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0
16:45	.145E-03	189	105	357	55	49	64	43	30	20	18	17	13	8	4	1	2	3	2	2	0	0	0	1	0	1	0	0	0	1	0	0	0	0	0	0
16:46	.211E-04	133	77	189	13	18	13	14	7	8	3	3	0	4	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16:47	.298E-05	175	175	175	6	1	2	2	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16:47	.818E-05	147	77	175	12	12	5	7	4	5	2	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16:48	.642E-04	161	77	301	33	41	48	31	25	16	10	7	3	2	5	1	1	0	0	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0
16:49	.267E-04	147	63	259	8	22	31	26	16	7	3	5	2	0	2	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
16:50	.273E-07	35	21	35	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16:51	.245E-05	77	63	105	6	4	6	3	3	3	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16:52	.134E-04	245	203	245	6	2	3	4	2	3	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16:53	.696E-04	441	315	441	1	2	3	2	5	1	1	2	0	1	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
16:54	.455E-05	175	63	175	7	5	6	3	4	2	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16:55	.194E-05	91	49	105	17	7	7	4	2	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16:56	.481E-04	441	441	441	10	3	8	3	2	4	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
16:57	.226E-04	203	77	259	29	14	6	8	11	7	0	6	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
16:58	.188E-04	175	91	259	4	3	7	6	8	4	5	1	2	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
16:59	.135E-05	91	49	91	18	3	2	6	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16:60	.746E-06	91	63	91	4	1	1	1	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16:61	.208E-05	119	119	119	1	0	0	3	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16:62	.783E-05	161	147	175	2	1	4	3	2	1	1	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16:63	.120E-04	105	63	161	15	15	15	18	8	6	2	4	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16:64	.373E-04	105	63	175	19	28	32	34	24	18	10	9	5	1	2	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16:65	.117E-04	105	49	147	12	22	23	22	11	6	2	1	1	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16:66	.489E-05	77	49	119	14	12	13	11	3	5	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16:67	.415E-04	371	91	371	13	24	24	17	17	5	7	3	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
16:68	.539E-09	7	7	7	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16:69	.598E-05	133	105	161	11	1	4	2	1	0	1	3	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16:70	.245E-04	329	133	329	2	6	3	3	5	0	2	2	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
16:71	.710E-04	147	91	217	21	46	47	37	26	15	12	8	8	5	4	1	2	2	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16:72	.384E-04	231	77	273	17	35	28	21	9	14	5	1	0	1	1	0	1	0	0	0	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
16:73	.322E-04	175	91	273	10	20	21	29	12	5	6	5	2	1	1	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
16:74	.316E-04	133	63	217	26	39	41	40	21	10	3	7	1	2	1	0	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16:75	.798E-05	203	189	203	0	1	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16:76	.480E-04	441	441	441	16	2	0	1	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
16:77	.891E-05	175	161	175	0	2	2	1	1	2	1	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16:78	.825E-05	147	63	175	6	9	13	9	5	2	0	0	2	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16:79	.189E-05	77	49	91	5	4	4	8	2	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16:80	.858E-05	203	77	203	6	6	7	3	6	1	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16:81	.373E-06	63	49	63	1	1	2	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16:82	.115E-05	77	63	91	1	1	1	2	1	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix D

DEW POINT COMPARISONS FOR LYMAN-ALPHA AND EG&G SENSORS

Appendix D

DEW POINT COMPARISONS FOR LYMAN-ALPHA AND EG&G SENSORS

Two dew point sensors were used in the June 1976 intensive tests, a Tarantula Lyman-Alpha optical absorption sensor and an EG&G variable temperature gold mirror sensor. The EG&G system provided stable repeatable measurements but inadequate time response. The Lyman-Alpha system provided the necessary time response but had a slight random drift of the baseline with a period of several minutes or longer.

The effect of Lyman-Alpha baseline drift was effectively eliminated by normalizing it to the stable EG&G baseline. A computer program was used to calculate the required baseline correction on a running average basis during normal data processing. The baseline corrections were made only during periods outside the plume by skipping times when the dew point was changing rapidly. Experimental evaluations show excellent correlation between the corrected Lyman-Alpha and EG&G dew points. A comparison of typical results obtained for the two sensors is provided in Figure D-1. Because of the consistent correlations, only the fast response Lyman-Alpha data are plotted in the final data presented in Volume 3. Both dew points are provided in the tabulated data in Volume 2.

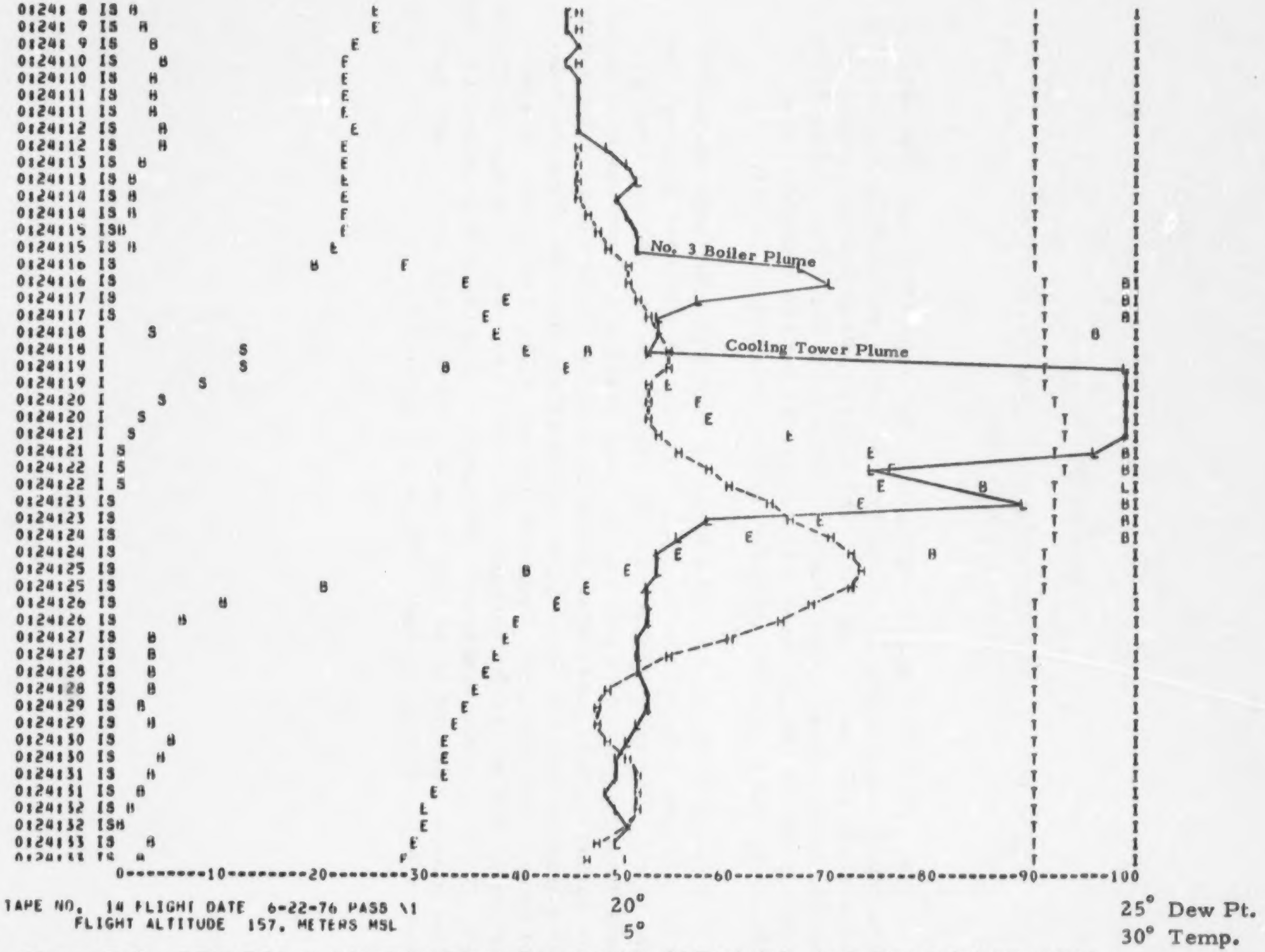


Figure D-1. DEW POINT COMPARISON FOR LYMAN-ALPHA (L), AND EG&G (H) SENSORS. Note the slower response and time lag of the EG&G Sensor.

Appendix E

ELEMENTAL ANALYSIS OF IMPACTOR SAMPLES BY IEXE

Appendix E

ELEMENTAL ANALYSIS OF IMPACTOR SAMPLES BY IEXE

Impactor samples from the first intensive tests in December 1975 were analyzed primarily for sodium and chlorine in order to determine sodium chloride concentration in the particles less than 30 μm diameter. Because the fluorescence analysis for sulfuric acid indicated concentrations below the detectable limits, the analysis for sulfur was also included. Results are summarized in Table E-1. Results of the IEXE analysis generally showed concentrations of all three elements that were below the detectable limits. Samples that included only a single pass through the plume were not analyzed because it was evident that even the more concentrated samples were insufficient to detect the available levels of sulfuric acid or sodium chloride.

Impactor samples from the second intensive tests in June 1976 were also analyzed. The sample flow rate of the impactor sampler during the first intensive tests was approximately 2 cfm. During the second intensive tests it was increased to 4.5 cfm in order to collect larger samples. The samples analyzed from the second set of tests contained up to 10 traverses through the plume for a cumulative sample volume of up to 5 ft^3 (0.14 m^3). Representative samples were analyzed, Table E-2, but concentrations were still found to be marginally detectable, Table E-3. Results indicated that sodium chloride concentrations on the impactor substrates are still below detectable limits. It appears that small quantities of sodium were detected on the filters (particles less than 0.4 μm dia.), but there was insufficient evidence to indicate that it was from sodium chloride. The sodium chloride molecule contains approximately 1.52 gm chlorine for each gram of sodium. If the sodium were from sodium chloride, the quantity of chlorine should be at least 1.5 times that of sodium. The analysis indicated less chlorine than sodium in every case.

TABLE E-1. ELEMENTAL ANALYSIS OF CASCADE IMPACTOR SAMPLES

Date (Flight Number)	Impactor Number	Pass Number	Na				Cl				S			
			Stage 1	2	3	Filter	1	2	3	Filter	1	2	3	Filter
15	1	8				---				299				120
(2)	2	14				---				---				---
	3	22				---				318				84
	4	24				---				293				
16	1	2-7				---				---				---
(3)	2	8				242				---				---
	3	9												
	4	10												
17	1	1-4	---	---	105	---	---	181	80	---	---	---	---	---
(5)	2	5-9	---	---	---	---	---	92	---	---	---	---	---	---
	3	10-14	---	103	156	---	---	133	113	---	---	---	87	---
	4	15-19	---	---	144	---	---	70	---	---	---	---	167	---
17	5	5-10	---	89	313	---	---	---	---	---	89	76	115	---
(6)	6	11-16	---	85	167	---	---	---	64	---	---	142	---	514
	7	17-27	---	282	132	183	---	133	---	---	---	---	260	---
	8	28-33	---	107	174	---	166	29	114	---	---	---	187	---
19	1	1-4	182	136	134	258	---	---	---	595	89	---	---	---
(7)	2	5-10	---	335	129	---	42	---	51	---	---	248	476	---
	3	11-22	79	71	134	---	---	---	---	218	---	147	---	---
	4	23-28	---	---	77	---	---	---	---	---	---	---	---	---
Minimum Detectable Level			150	150	150	340	108	108	108	210	100	100	100	180

Notes:
1. Date indicates the day in December 1975 during which measurements were made.
2. A blank in the table indicates that the sample was not analyzed; a dash indicates that the sample was analyzed but the concentration was below the detectable limit.
3. Numbers smaller than the minimum detectable level have little statistical significance.

TABLE E-2. DESCRIPTION OF IMPACTOR SAMPLES ANALYZED

Test Number	8		11	12			15	
Impactor Number	1	4	3	1	2	3	1	2
Altitude (ft)	1200	500	400	300	300	300	700	600
Downwind Distance*	1	1	1	1	3	4	2	4
Pass Numbers included in impactor samples	1 8 9 10 16 17 24 25 32 33 40 41	4 5 12 20 21 28 29 36 37 44	5 8 17 20 29	1 2 3 4 5 6 7 8 9 10	11 12 13 14 15 16 17 18 19	20 21 22 23 24 25 26 27 28 29	58 59 60 61 62	63 64 65 66 67
Number of Passes	12	10	5	10	9	10	5	5
Slide No. for Analysis								
Stage 1	4	8	12	20	24	28	32	
2	5	9	13	21	25	29	33	
3	6	10	14	22	26	31	34	36
Filter	7	11	15	23	27	30	35	

*Downwind Distance

1. Cloud to tower
2. Midway in visible plume
3. End of visible plume
4. Beyond visible plume

TABLE E-3. ELEMENTAL ANALYSIS RESULTS FOR IMPACTOR SUBSTRATES

```
                      UC DAVIS ELEMENTAL ANALYSIS       TRAY 31502     07/21/76            O/P ON 07/26/76

                      NA TO TOTLK IN NANOGRAMS/CM**2    TOTLK FROM NA TO PB

SLIDE       NA               MG               AL               SI                S                  CL                K
  4       271.0*       393.1 +/-  78.3      166.0*       1083.4 +/- 192.8     210.0*              190.0*            144.0*
  5       283.0*           177.0*           179.0*           175.0*           233.0*              210.0*            160.0*
  6       259.0*        72.5 +/-  49.5      163.0*           160.0*        921.4 +/- 122.2        191.0*            146.0*
  8       326.0*           203.0*           206.0*           201.0*           268.0*          124.4 +/-  86.9       184.0*
  9       435.0*           272.0*       214.7 +/-  73.7   402.0 +/- 119.5     358.0*              322.0*        122.0 +/-  60.6
 10   156.4 +/- 110.2      197.0*           199.0*           195.0*           260.0*          369.7 +/-  85.4       179.0*
 12       512.0*           320.0*           324.0*           317.0*           422.0*          282.1 +/- 161.2       291.0*
 13       335.0*       281.1 +/-  66.7      212.0*       1295.6 +/- 177.7     276.0*              248.0*        167.7 +/- 121.0
 14       263.0*        85.6 +/-  43.6  265.6 +/-  58.2   497.9 +/-  87.4     216.0*              195.0*            149.0*
 16       252.0*       162.0 +/-  50.6      159.0*           156.0*           208.0*          251.5 +/-  75.9    97.3 +/-  91.7
 17       362.0*           226.0*       333.3 +/-  80.1   123.3 +/-  54.4     298.0*          387.5 +/- 102.4       205.0*
 18       325.0*           203.0*       399.6 +/- 101.7      201.0*           267.0*          176.4 +/-  94.8       184.0*
 20       256.0*           160.0*       389.7 +/- 105.0      158.0*           211.0*          278.9 +/- 109.8   197.5 +/-  95.2
 21       184.0*           115.0*           116.0*           114.0*           151.0*           72.4 +/-  56.8   179.9 +/-  42.7
 22       180.0*           112.0*           113.0*           111.0*           147.0*              133.0*        138.4 +/-  66.5
 24       136.0*            85.0*            86.0*        631.0 +/-  30.7     112.0*              101.0*             77.0*
 25       259.0*           162.0*       458.4 +/- 147.3   551.7 +/- 131.4     213.0*          368.3 +/-  79.3       147.0*
 26       250.0*       174.3 +/-  50.5  455.5 +/- 114.2   417.0 +/- 124.8     205.0*              184.0*        169.3 +/-  91.4
 28       288.0*           180.0*           182.0*           178.0*           237.0*              213.0*            163.0*
 29       218.0*           135.0*           137.0*           134.0*           178.0*          342.3 +/-  83.4       122.0*
 31       263.0*           164.0*        76.5 +/-  44.5      163.0*           217.0*              195.0*            149.0*
 32       202.0*       466.1 +/-  88.9      127.0*       1014.5 +/- 134.0     165.0*          288.5 +/-  88.0   141.6 +/-  74.0
 33       199.0*       164.4 +/-  55.1      125.0*           123.0*           163.0*              147.0*            112.0*
 34   255.4 +/- 147.4  146.9 +/-  98.1  212.8 +/-  95.5      153.0*           217.0*          136.4 +/-  71.3       150.0*
 36       201.0*       210.4 +/-  86.5      127.0*        814.0 +/- 118.8     166.0*          120.4 +/-  48.2       114.0*
```

TABLE E-3. ELEMENTAL ANALYSIS RESULTS FOR IMPACTOR SUBSTRATES (Continued)

SLIDE	CA	TI	V	CR	MN	FE	NI
4	207.0*	100.0*	251.5 +/- 43.9	147.4 +/- 32.8	88.0*	148.7 +/- 50.6	90.0*
5	231.0*	108.0*	98.3 +/- 29.4	96.0*	92.0*	89.0*	98.0*
6	211.0*	63.2 +/- 31.0	287.9 +/- 45.5	38.0*	84.0*	74.6 +/- 28.8	89.0*
8	266.0*	125.0*	127.0*	111.0*	106.0*	197.8 +/- 39.0	53.5 +/- 29.2
9	712.2 +/- 130.8	167.0*	169.0*	148.0*	142.0*	203.5 +/- 58.0	150.0*
10	258.0*	92.3 +/- 58.2	123.0*	107.0*	103.0*	99.0*	108.0*
12	718.0 +/- 147.9	554.0 +/- 103.7	200.0*	175.0*	120.3 +/- 53.0	238.6 +/- 59.4	176.0*
13	274.0*	128.0*	131.0*	244.9 +/- 87.5	109.0*	431.3 +/- 66.3	115.0*
14	215.0*	101.0*	89.9 +/- 33.4	90.0*	86.0*	52.4 +/- 28.6	91.0*
16	206.0*	97.0*	188.0 +/- 35.8	86.0*	78.1 +/- 26.1	79.0*	87.0*
17	295.0*	139.0*	141.0*	124.0*	113.0*	210.9 +/- 40.3	124.0*
18	265.0*	124.0*	126.0*	111.0*	106.0*	102.0*	112.0*
20	209.0*	98.0*	226.4 +/- 44.3	37.0*	84.0*	80.0*	88.0*
21	150.0*	73.0*	76.0*	66.0*	64.0*	315.7 +/- 44.6	64.0*
22	146.0*	1471.8 +/- 450.3	70.0*	52.0*	59.0*	173.4 +/- 38.4	62.0*
24	111.0*	203.0 +/- 32.5	53.0*	46.0*	44.0*	43.0*	47.0*
25	212.0*	99.0*	101.0*	88.0*	85.0*	400.8 +/- 53.0	89.0*
26	203.0*	179.1 +/- 80.8	98.0*	86.0*	82.0*	701.1 +/- 79.5	86.0*
28	235.0*	110.0*	278.4 +/- 55.0	98.0*	48.0 +/- 27.6	157.3 +/- 36.6	99.0*
29	176.0*	133.0 +/- 39.5	85.0*	74.0*	100.8 +/- 29.2	68.0*	74.0*
31	215.0*	102.0*	104.0*	91.0*	223.1 +/- 59.9	270.0 +/- 41.9	91.0*
32	163.0*	77.0*	78.0*	68.0*	93.4 +/- 26.4	63.0*	69.0*
33	162.0*	76.0*	185.8 +/- 35.8	58.0*	65.0*	119.2 +/- 25.5	63.0*
34	216.0*	101.0*	103.0*	90.0*	86.0*	83.0*	91.0*
36	164.0*	77.0*	200.0 +/- 45.1	59.0*	65.0*	63.0*	59.0*

TABLE E-3. ELEMENTAL ANALYSIS RESULTS FOR IMPACTOR SUBSTRATES (Continued)

SLIDE	CU	ZN	BR	BA	PB	TOTLX
4	71.0*	130.6 +/- 31.2	103.0*	1275.8 +/- 245.5	203.0*	3430.4 +/- 329.4
5	79.0*	106.0*	103.0*	355.0*	203.0*	98.3 +/- 29.4
6	72.0*	96.0*	95.0*	324.0*	188.0*	1424.6 +/- 145.8
8	90.0*	122.0*	117.0*	409.0*	231.0*	375.7 +/- 99.7
9	121.0*	162.0*	174.0*	547.0*	343.0*	1654.5 +/- 209.4
10	86.0*	116.0*	200.0*	396.0*	395.0*	628.4 +/- 151.0
12	141.0*	189.0*	256.0*	645.0*	506.0*	2023.0 +/- 254.9
13	92.0*	124.0*	185.0*	421.0*	366.0*	2420.6 +/- 250.4
14	73.0*	98.0*	94.0*	330.0*	187.0*	991.4 +/- 122.0
16	70.0*	94.0*	97.0*	962.9 +/- 205.6	192.0*	1739.8 +/- 246.9
17	100.0*	135.0*	135.0*	2369.7 +/- 366.6	267.0*	3424.7 +/- 394.8
18	90.0*	121.0*	125.0*	788.1 +/- 272.4	248.0*	1364.2 +/- 305.8
20	71.0*	95.0*	105.0*	322.0*	208.0*	1092.5 +/- 164.8
21	51.0*	120.3 +/- 27.3	114.0*	241.0*	226.0*	688.2 +/- 58.3
22	50.0*	67.0*	64.0*	1800.5 +/- 472.9	127.0*	3584.0 +/- 657.5
24	38.0*	51.0*	59.0*	171.0*	117.0*	833.9 +/- 87.0
25	72.0*	97.0*	88.0*	326.0*	174.0*	1779.2 +/- 219.2
26	69.0*	93.0*	88.0*	314.0*	175.0*	2096.8 +/- 228.9
28	80.0*	107.0*	98.0*	362.0*	194.0*	483.7 +/- 71.6
29	60.0*	51.4 +/- 21.8	93.0*	272.0*	184.0*	627.5 +/- 99.2
31	73.0*	98.0*	99.0*	333.0*	195.0*	569.6 +/- 65.6
32	56.0*	75.0*	89.0*	252.0*	175.0*	2004.1 +/- 199.5
33	55.0*	76.4 +/- 23.2	84.0*	1064.4 +/- 201.7	166.0*	1610.2 +/- 214.9
34	73.0*	60.1 +/- 24.3	99.0*	573.9 +/- 175.3	196.0*	1385.6 +/- 277.3
36	56.0*	75.0*	87.0*	253.0*	171.0*	1344.8 +/- 161.4

* DENOTES UPPER LIMIT OF ELEMENT NOT FOUND

ADDITIONAL ELEMENTS FOUND: SLIDE, ELEMENT, AMOUNT

4	F	389.8
5	P	420.9
8	F	443.6
10	P	154.8
13	P	256.3
14	P	405.8
20	P	128.4
21	CO	203.7
22	P	648.9
24	P	55.6
25	P	219.3
25	P	759.2
28	P	268.4
29	P	120.9
32	P	336.7
33	P	194.8
34	P	67.5
36	P	127.5

Minimum sensitivity for P ≈ 200 ng/cm^2

TABLE E-3. ELEMENTAL ANALYSIS RESULTS FOR IMPACTOR SUBSTRATES (Concluded)

```
SLIDE        NA                  MG                  AL                  SI                  S                   CL                  K
  7   140.0 +/-  43.1     57.8 +/-  22.5    115.6 +/-  24.2      73.0*              61.0*               60.0*           20.5 +/-   9.7
 11    76.3 +/-  28.7     86.4 +/-  20.8     94.3 +/-  39.3    178.2 +/-  55.1    62.9 +/-  15.4     26.1 +/-  12.4       36.0*
 15    95.9 +/-  54.4    130.5 +/-  26.7      78.0*              70.0*              59.0*               58.0*              35.0*
 19      115.0*           44.5 +/-  20.9      74.0*             83.9 +/-  17.8    41.7 +/-  15.2        55.0*              36.0*
 23      132.0*          137.5 +/-  30.7      85.0*              76.0*              64.0*            76.8 +/-  20.1       41.0*
 27   106.3 +/-  32.9    110.0 +/-  22.6      77.0*             67.0 +/-  24.6      57.0*               56.0*              37.0*
 30      119.0*           81.0 +/-  23.7      76.0*              68.0*            31.4 +/-  14.4        56.0*              37.0*
 35   154.2 +/-  65.0       79.0*            60.1 +/-  23.6    139.7 +/-  23.1    88.3 +/-  17.5     44.9 +/-  15.0    16.3 +/-  11.5

SLIDE        CA                  TI                  V                   CR                  MN                  FE                  NI
  7       29.0*              29.0*            23.4 +/-   3.5      26.0*               25.0*               24.0*              25.0*
 11       27.0*              27.0*               27.0*            24.0*               23.0*            33.9 +/-   8.8       23.0*
 15    37.3 +/-  10.3        28.0*            28.1 +/-   9.4      25.0*               23.0*               23.0*              24.0*
 19       27.0*              27.0*               27.0*            24.0*            11.1 +/-   6.2         22.0*              23.0*
 23       30.0*              31.0*               31.0*            27.0*            16.5 +/-   7.3         25.0*              25.0*
 27       27.0*              28.0*            18.7 +/-   8.3      25.0*               23.0*               23.0*              24.0*
 30    20.5 +/-   9.4        28.0*            12.1 +/-   3.1      25.0*               23.0*               23.0*              24.0*
 35       28.0*              29.0*            55.2 +/-  10.4      25.0*               24.0*            16.7 +/-   7.7       24.0*

SLIDE        CU                  ZN                  BR                  BA                  PB                TOTLX
  7       21.0*              26.0*               33.0*               96.0*               66.0*          357.5 +/-  55.8
 11       20.0*           10.2 +/-   6.3         28.0*               89.0*               56.0*          568.4 +/-  79.6
 15       20.0*              25.0*               29.0*               92.0*               57.0*          291.9 +/-  62.2
 19       19.0*              24.0*               30.0*               88.0*               60.0*          181.2 +/-  52.0
 23       22.0*              27.0*               33.0*              100.0*               64.0*          230.8 +/-  57.5
 27       20.0*              25.0*               29.0*               91.0*               58.0*          302.0 +/-  47.6
 30       20.0*              25.0*               29.0*               91.0*               57.0*          145.0 +/-  50.4
 35       21.0*              25.0*               31.0*               93.0*               61.0*          575.4 +/-  78.4

         * DENOTES UPPER LIMIT OF ELEMENT NOT FOUND

ADDITIONAL ELEMENTS FOUND: SLIDE, ELEMENT, AMOUNT
   7  P    173.1              11  P     76.4               19  P     74.8              30  P     89.9
```

Minimum sensitivity for P ~70 ng/cm^2

Appendix F

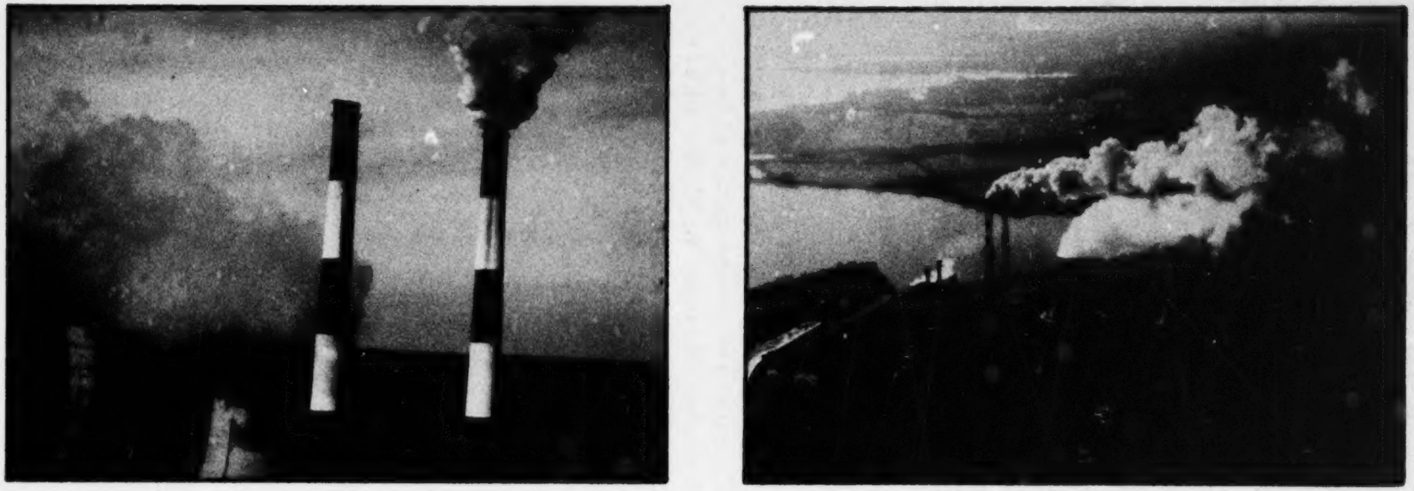
PLUME PHOTOGRAPHS

Appendix F

PLUME PHOTOGRAPHS

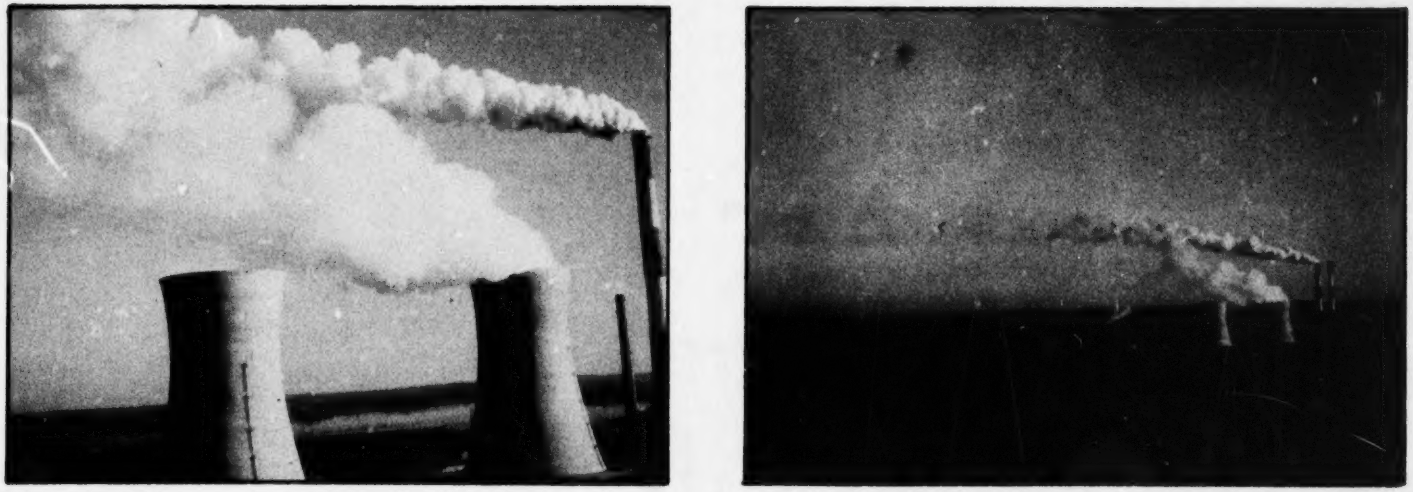
Photographs of typical plumes were taken from the sampling aircraft on most of the test days. These photographs provide an indication of the size and shape of the visible plume, plume rise, and the general weather conditions. The photographs are helpful in evaluating the results obtained from the quantitative plume measurements.

For the June 1976 tests, four photographs are shown for each test. The first photograph is representative of the beginning of the test, the last one was taken near the end of the test, and the other two were taken at intermediate times. The series of photographs shows changes in plume characteristics during the tests, some of which extended over a four-hour period.



Test 3

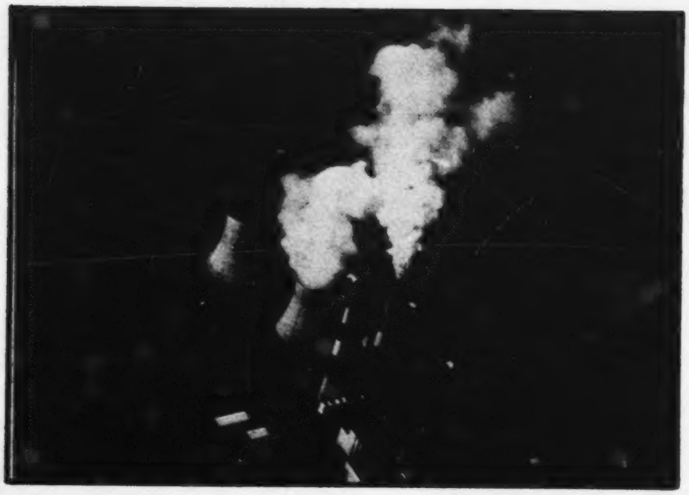
Test 5



Test 5

Test 5

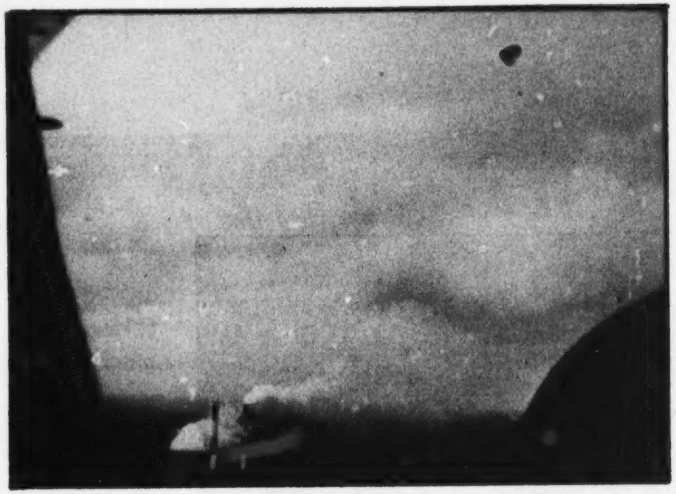
Figure F-1. Tests 3-5, December 16, 17, 1975.



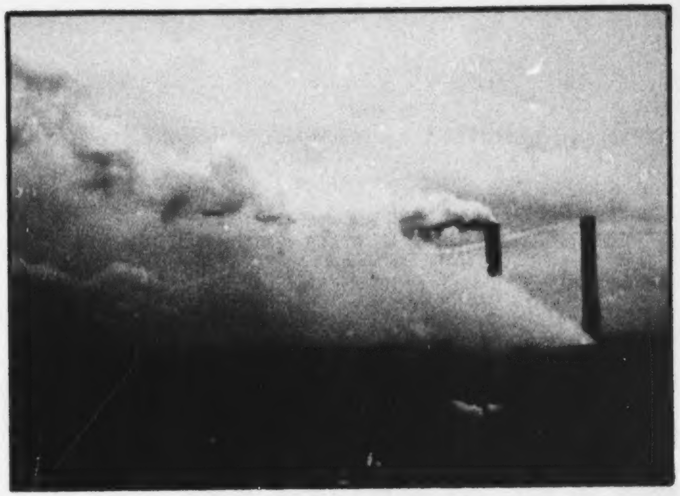
Test 6

Test 6

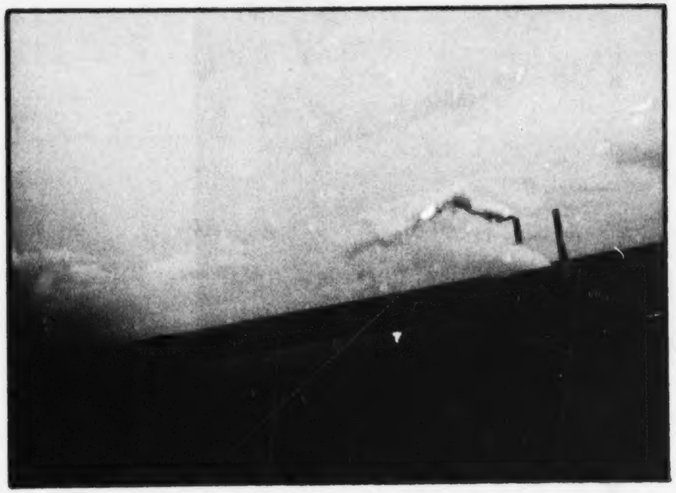
Figure F-2. Test 6, December 17, 1975



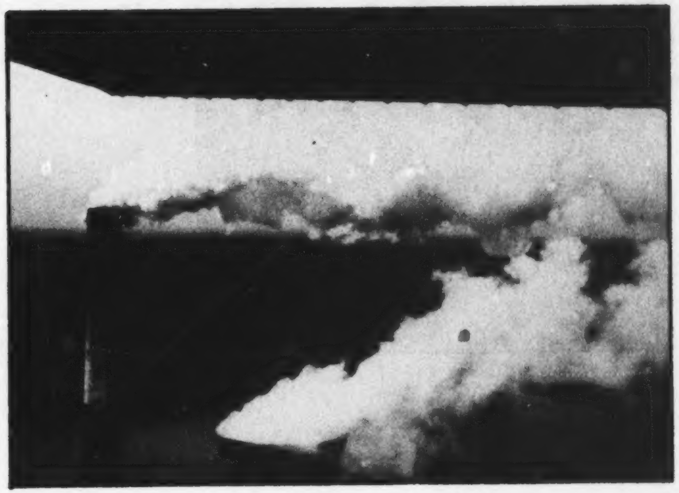
Traverse 1



Traverse 4

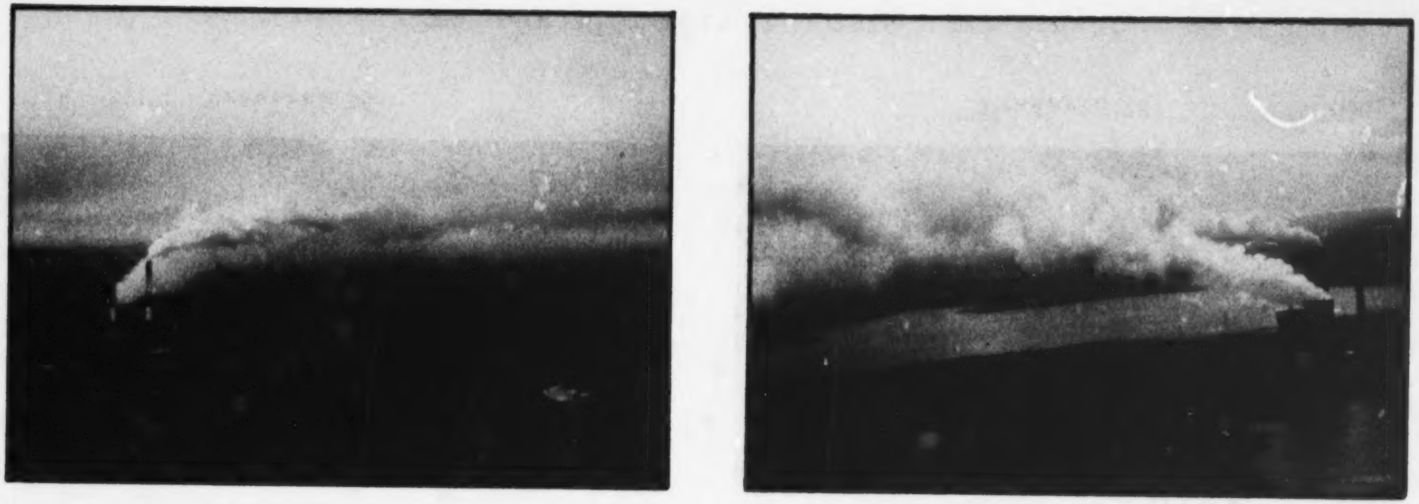


Traverse 7



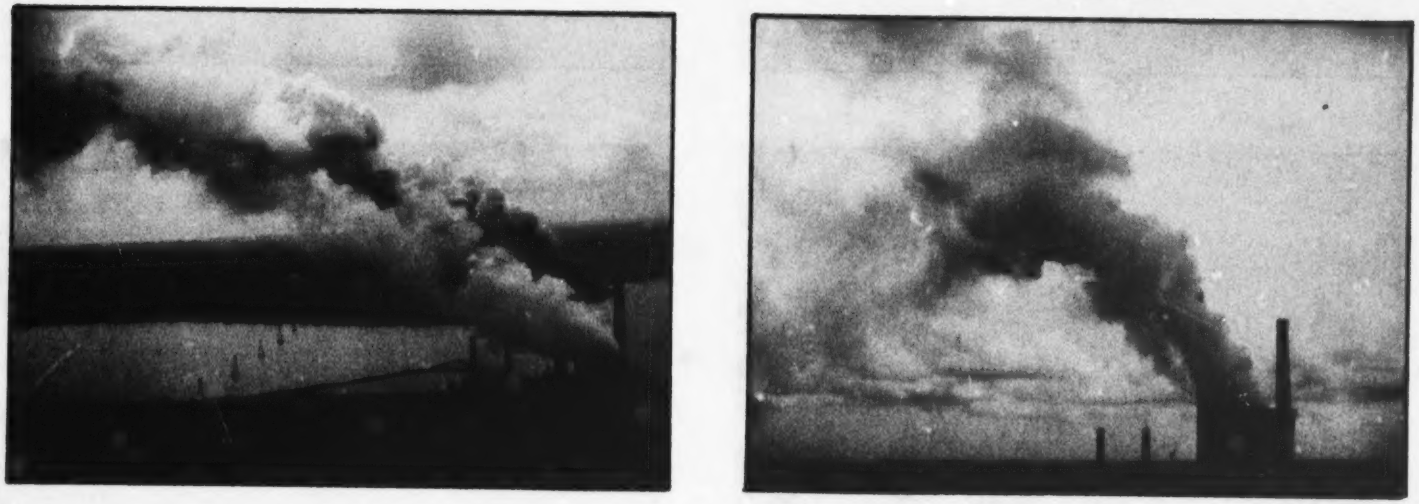
Traverse 10

Figure F-3. Test 13, June 1976



Traverse 1

Traverse 17



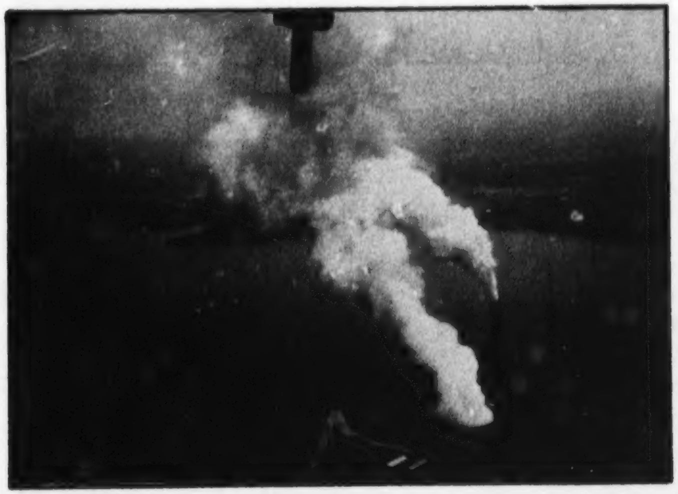
Traverse 39

Traverse 90

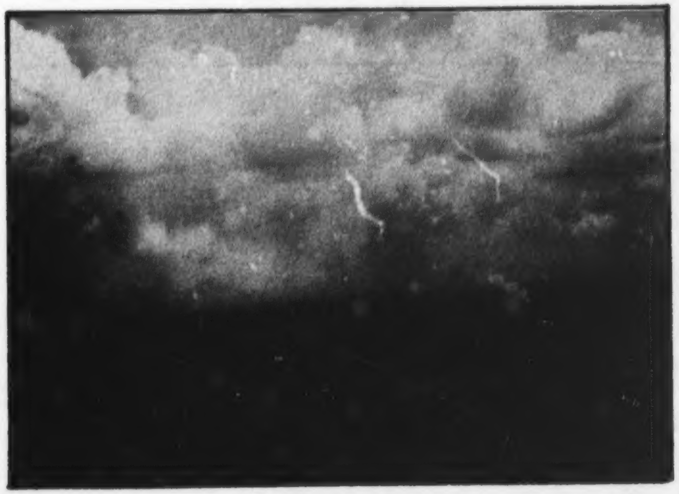
Figure F-4. Test 14, June 1976

Traverse 1

Traverse 13

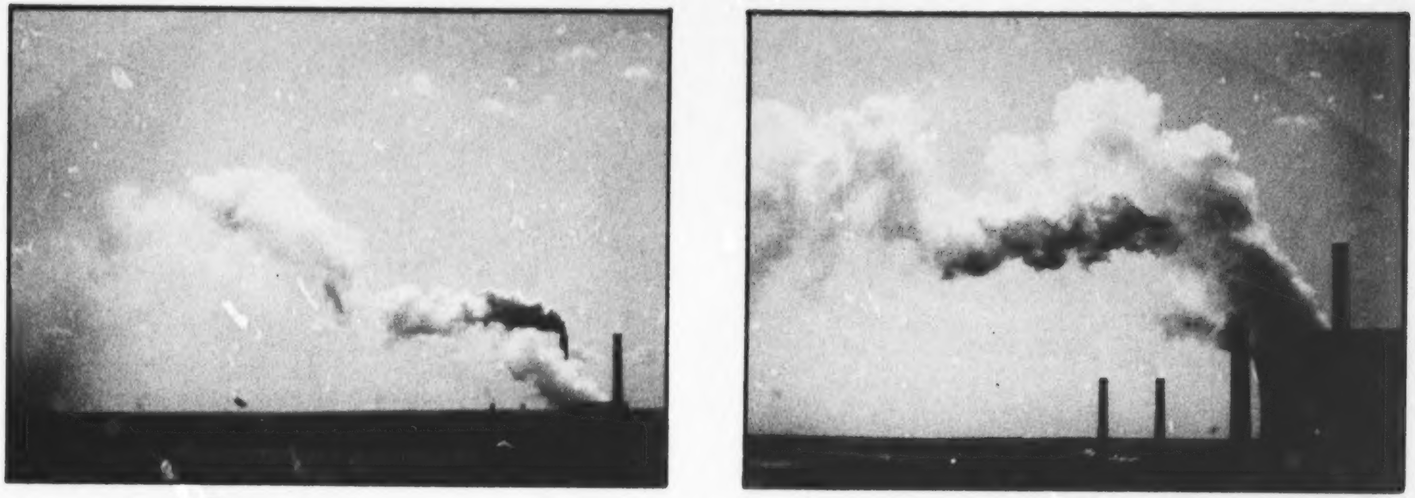


Traverse 36



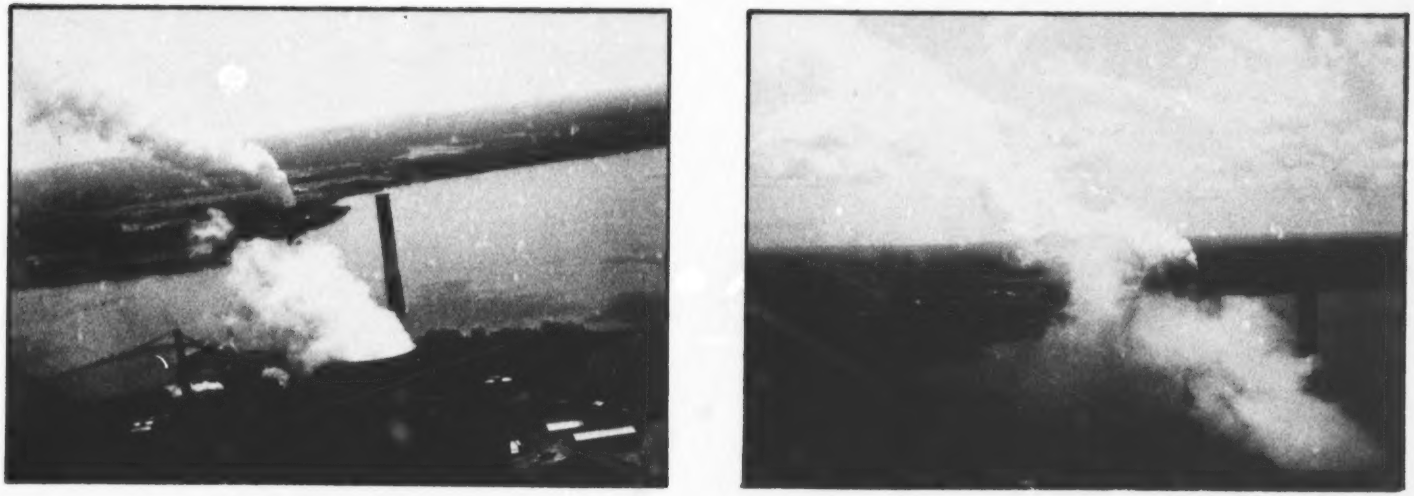
Traverse 75

Figure F-5. Test 15, June 1976



Traverse 1

Traverse 21



Traverse 47

Traverse 63

Figure F-6. Test 16, June 1976

Appendix G

UNITS CONVERSION TABLE

Appendix G

UNITS CONVERSION TABLE

To Convert From	To	Multiply By
mils	meters	2.54×10^{-5}
inches	meters	0.0254
feet	meters	0.3048
pounds	kilograms	0.4536
pounds/inch^2 (psi)	newtons/meter^2	6.8948×10^{-3}
miles/hour (mph)	meters/second	0.4470
feet^3/minute (cfm)	meters^3/minute	0.0283